Electronics World

MAY, 1970
60 CENTS

DESIGNING A HI-FI WOOFER ENCLOSURE
Do You want to Be CHIEF ENGINEER OF A RADIO STATION?
USING POWER LINE AS A TIME STANDARD
RCA'S SOLID-STATE COLOR CHASSIS

POWER TRANSISTORS

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 10 seconds in 1970. 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 a minimum 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."* Bay City, Michigan.

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."* New Ringgold, Penna.

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..."* Dayton, Ohio.

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 2000 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.

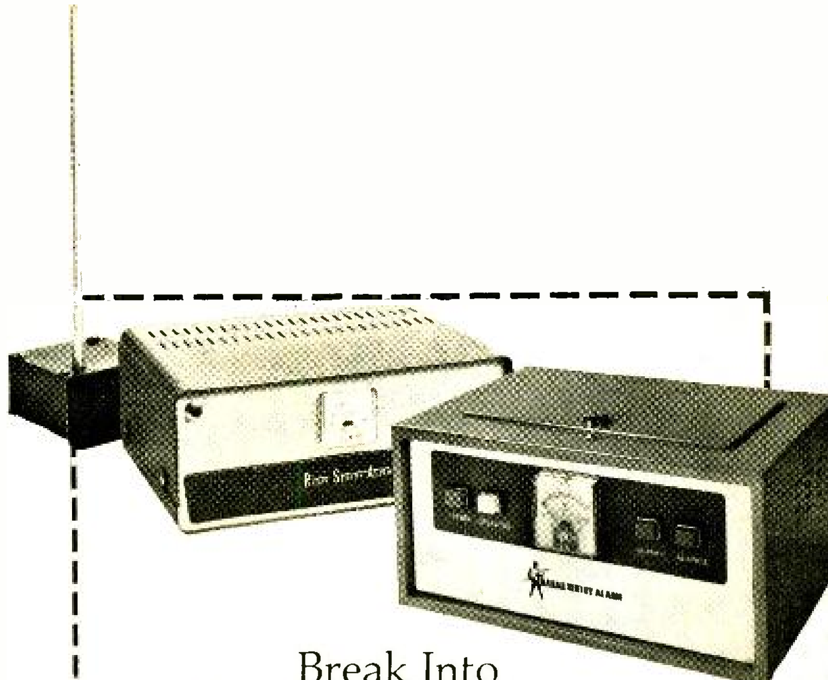
Ride the crime wave today

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.
- a minimum investment.
- 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-5-70
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. 128 ON READER SERVICE CARD

Crime does pay.

If you're an alert distributor.

Because we are introducing a new product with a suggested retail list of $89.95 that will sound a warning when it detects an intruder, vandal or trespasser. It's the Mallory Crime Alert® ultrasonic intruder alarm.

This new Mallory product is easy to stock—no time consuming installation—no big warehouse space needed. It's bound to be a sure-fire seller because it's so beautifully simple and effective. It gives 24-hour surveillance for homes, offices, stores and plants at small cost and needs no maintenance.

In use, there are no wires, no light beams, no door and window devices . . . just the compact Crime Alert unit itself. Set up in a room or hall, it sends out continuous ultrasonic waves that can't be seen, heard, or avoided. Yet the smallest movement is detected in a split second, activating the built-in alarm and any spotlights, sirens, recorders or other devices plugged into it.

The same type of system is used in the Pentagon to guard the security of top secret areas. It's an item everybody needs today. So put in an order now.

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MALLORY DISTRIBUTOR PRODUCTS COMPANY
a division of P. R. MALLORY & CO. INC.
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ACTUAL SIZE

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Electronics World

MAY 1970 VOL. 83 NO. 5

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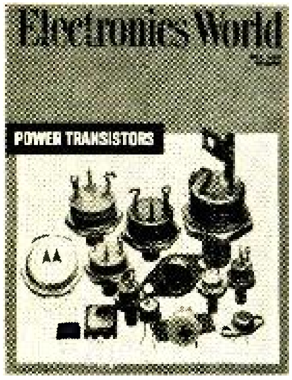

THIS MONTH'S COVER shows a grouping of some of the newer power transistors that are now available. These are better products and at lower prices as a result of improvements in die design, production techniques, and in final packaging. For a status report on power transistors, refer to our lead story this month. All transistors shown are from Motorola. Cover photograph: Dirone-Denner.

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Coming Next Month

Special Feature Article

EW Lab Tests AUTOMATIC TURNTABLES

What should you look for when you shop for an automatic turntable? Is price an accurate criterion of quality? Hirsch-Houck Labs tested 17 models from five manufacturers to give you valuable guidance before making your choice. Read before you shop!

SONIC HOLOGRAPHY

Sound waves, as well as laser beams, can produce holograms and recreate 3-dimensional images. Since sound waves penetrate, some holograms are capable of providing "inside" 3-D views of the human body, castings, and even oil deposits lurking beneath the sandy wastes of the desert.

AUTOMATIC VEHICLE MONITORING

Emergencies mean fast response by police or fire departments to keep loss of human life and property to a minimum. A new system which uses the principles of loran and air-traffic identification transponders to pinpoint location of such emergency vehicles promises faster response and better deployment of manpower by urban security forces.

ADD-SUBTRACT MOS IC DECIMAL COUNTER

Here are details on a unique counter that uses a single IC and a readout per decade to perform a wide variety of operations.

HIGH-QUALITY AM SECTION IN NEW RECEIVER

Using a four-pole filter, an FET front-end, and an IC i.f. strip, this new AM tuner section compares favorably with the FM tuner quality in a number of Scott hi-fi receivers, including 382-C, 386, 3800, and 3900.

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

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Every minute is longer up there.

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

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

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

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

Even more care goes into the electronics.

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

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

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

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

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

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Here's where we can save you time.

For the record

WM. A. STOCKLIN, EDITOR

Pollution Control—A New Industry

ONE rarely reads a newspaper or listens to a news report without seeing or hearing some comment on pollution. Even a year ago, students were protesting against the poisoning of our environment. Today, there are still many of them paying more attention to this problem than to the war in Vietnam.

It doesn't really need much convincing to realize the seriousness of the problem. One simply has to take a look at the Chicago River, or our own Hudson River here in New York (and there are many others) to recognize how polluted our waters are. Those unfortunate individuals living near any of our jet airports can vouch for the problems of noise. And certainly anyone who has visited or lived in Los Angeles (or Phoenix, or New York) and has seen the city at its peak of smog, needs no further proof of air pollution.

President Nixon has pledged his administration to a "now or never" fight and, in his recent State of the Union message, proposed a 5-year, $10-billion program—financed partially by the Federal Government—to help solve some of these problems. The intent behind his message was enthusiastically received and we are convinced of his determination to do everything in his power to stop environmental erosion.

But is $10 billion enough? *General Motors* alone grossed slightly over $24 billion last year. If $10 billion is to be divided among all the states, cities, and towns in our country, not much will be available for each one. *Merrill Lynch, Pierce Fenner & Smith*, in a recent bulletin, pointed out that Sen. Jackson of Washington estimates it would cost $26-$29 billion during the next 5 years to do an "acceptable job of cleaning the nation's waterways; $12-$15 billion to clean the air in metropolitan areas; and $15 billion to dispose of solid wastes without adding to pollution." It seems that it would take $10 billion annually to abate the problem and even this may be insufficient. It has been mentioned that $5.4 billion has already been spent in the last 12 years to reduce water pollution, without noticeable results. A recent Federal study recommends $1.4 billion be spent immediately to prevent further contamination of Lake Erie.

Even though Federal funds are inadequate, there are enough laws against pollution to force states, cities, and even private companies to add their own dollars to prevent further contamination.

We have just been informed that the National Air Pollution Control Administration (a Federal agency) will soon issue strict limits on the amount of carbon monoxide and other pollutants permitted in the atmosphere. These limits will be used by the states as guidelines, and apply only to stationary polluters. Motor vehicles are regulated by the nationwide Federal emission standards.

A New Industry

If present efforts continue—and there is no reason why they won't—a new industry has been born—Pollution Control. It is certainly diffused at present; not wholly electronic, chemical, or any other branch of industry, but a combination of all fields. There will be hundreds of companies involved, with no single company ever being predominant. Daily reports indicate great interest in the subject, and many companies are developing new divisions for pollution research. Among others, *Gulf Oil Corp.* recently announced its entrance into the field.

Following normal procedure, the first approach would be analysis of the problem (with research organizations and consulting firms playing the major role); then analysis of the specific pollutants (measuring types and amounts); and next the basics of actually reducing contamination. The final task would be to develop monitoring systems to serve as policing controls.

Electronically, the area of measuring and monitoring is the most exciting. Instrument manufacturers do not know how much equipment is involved in pollution control in today's market, nor do they have any idea of how big a market it may be for them in the future. We have heard it could reach as high as 20% of the total test equipment/instrumentation market. Unfortunately, no one knows precisely what type of equipment will be required. Certainly, electro-optic and infrared instruments of various types will be used, as well as spectrometers, gas analyzers, radiation-measuring equipment, lasers, computers, oscilloscopes, sophisticated noise-level instruments, and digital voltmeters and timers of all types. In fact, it has been suggested that infrared equipment in a plane can be used to locate and determine the amount of thermo-pollution in waterways.

As for basic hardware, the electronic precipitator for purification has the greatest potential. We've also heard there is a widening future in water pollution control for such sophisticated equipment as plasma-arc processors.

Although there apparently is not enough money at present, a new industry has been born, and electronics will play a major role in it in the 1970's. ▲

HI-FI PRODUCT REPORT

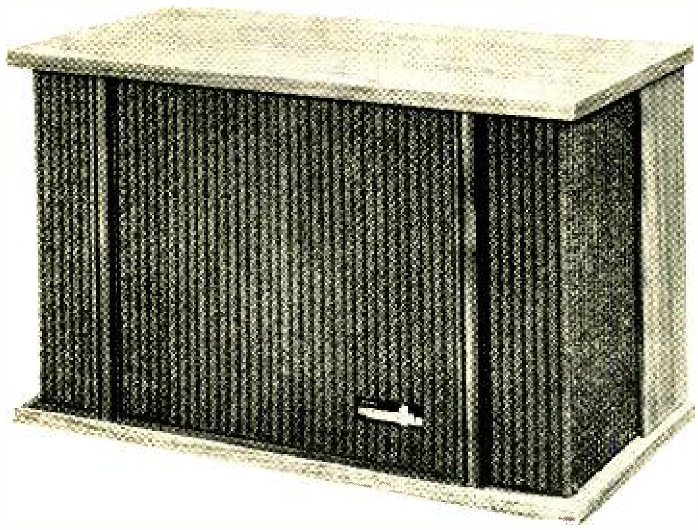
EW LAB TESTED

by Hirsch-Houck Labs

Jensen Stereo I Speaker System
Shure V-15 Type II (Improved) Cartridge

Jensen Stereo I (S-100) Speaker System

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



ONLY rarely does a really new concept appear in the high-fidelity equipment field. We think that the *Jensen* Stereo I (Model S-100) approach qualifies as an innovation—at least, we do not recall having seen anything like it during our two decades in audio.

The Stereo I system is a method of producing true stereo sound from a single, compact speaker enclosure. It employs acoustic matrixing—similar in concept to the electronic matrixing sometimes used in stereo-FM multiplex systems—to produce a real stereo image from a single enclosure. The matrix system (for which patents are pending), employs three drivers. One faces forward, the other two are mounted on opposite sides of a vertical board which bisects the forward-facing speaker opening and is at right angles to it. As far as we can determine, there is no crossover network, so that all drivers handle the full frequency range. The side-facing drivers, being essentially unbaffled, do not reproduce low frequencies, but have heavy magnets and compliant suspensions to handle large cone excursions without "bottoming."

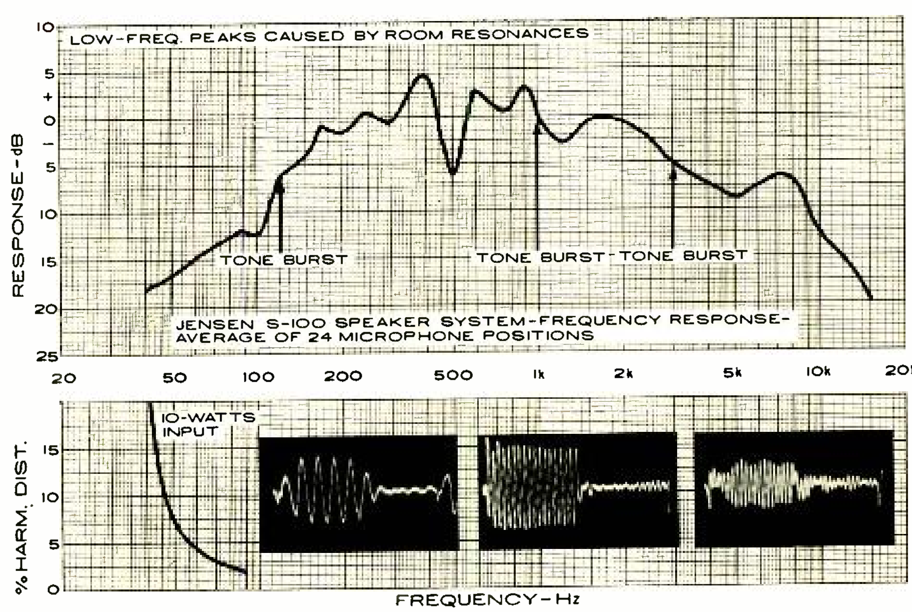
The left- and right-channel inputs, which have a nominal impedance rating of 8 ohms, go to a matrixing transformer within the enclosure. The two channels are summed and applied as (L+R) to the forward-facing speaker. Their difference (L−R) goes to the side-facing speakers, which are connected electrically out-of-phase so that they act as in-phase drivers, facing in opposite directions.

A mono signal has no (L−R) components, and is radiated entirely by the forward-facing speaker. When the forward- and side-facing speakers are driven in-phase, the acoustic output is (L+R)+(L−R) = 2L, equivalent to a left-channel output. The right-channel output is created by an out-of-phase combination, (L+R)−(L−R) = 2R.

Jensen engineers have made measurements with directional microphones that prove the reality of the stereo image produced by this system. Our ears led us to the same conclusion. The system works to a degree that is nothing short of amazing. The size of the listening room, or the placement of the speaker within it, seems to have little to do with the spread of the stereo image. The applications of the speaker to very small rooms, or in boats, travel trailers, or mobile homes, are obvious. Many people lack room or for other reasons cannot accommodate two speaker systems, even of small size, with reasonable spacing. It is hard to imagine a listening environment that could not utilize this unit to provide stereo reproduction.

Thus far we have discussed only the stereo performance of the speaker. What about its sound quality? This unit, by itself, has some characteristics which prevent it from matching the sound of many conventional speaker systems of comparable price. In fairness to the manufacturer, they emphasize the ability of the speaker to bring stereo where it could not be enjoyed before, rather than to replace conventional speakers where they can be used.

The weakness of the Stereo I is its constricted sound on mono programs. Only the forward-facing speaker operates on mono, and its front is blocked by the side-facing speakers and a solid panel inside the face of the cabinet. Highs are reduced, and the sound has a "contained" character. Switching to stereo "opens up" the sound in a most impressive manner, although it is "medium-fi" rather than "hi-fi."



We measured the frequency response of the speaker with more than our usual 8-microphone array. Using various combinations of mono and single-channel driving signals, we average a total of 24 microphone outputs throughout the room to obtain what we believe to be a realistic picture of the total output of the speaker. The middle frequencies, from about 150 Hz to 2 or 3 kHz, are produced with reasonable uniformity, but the output falls off at low and high frequencies. Tone bursts are reproduced very well at some frequencies, and poorly at others, but the over-all transient response is quite acceptable for a moderately low-priced speaker (which this one really is). The low-frequency harmonic distortion is fairly low down to 50-60 Hz, but rises at lower frequencies.

When we examined the drivers and construction, we understood the reasons for the limited bass and high-end response. The forward-facing speaker is only 6½" in diameter, and is loaded by an enclosed volume of about ⅝ cubic foot. In view of this, one could hardly expect any extended low-frequency output from the system. The obstructions in front of the speaker reduce its effective high-frequency radiation.

The side-facing drivers are 4" in diameter and are unbaffled. They do their job well, aided by magnet structures nearly as large as the cones and baskets.

To summarize, the *Jensen* Stereo I is (we hope) the first of a series of acoustical-matrixing speaker systems. Its overall dimensions are 13" high by 21¾" wide by 11⁹⁄₁₆" deep, and it weighs less than 30 pounds. It is an attractively styled unit, and can bring a good stereo image into locations where this was previously impossible. Its sound is too limited for our taste, but can be improved to some extent by tone controls.

We would like to view the speaker as a limited application of a novel principle, and would really like to see what the company could do with a somewhat larger enclosure and drivers. The *Jensen* Stereo I sells for $124.95. ▲

Shure V-15 Type II (Improved) Cartridge

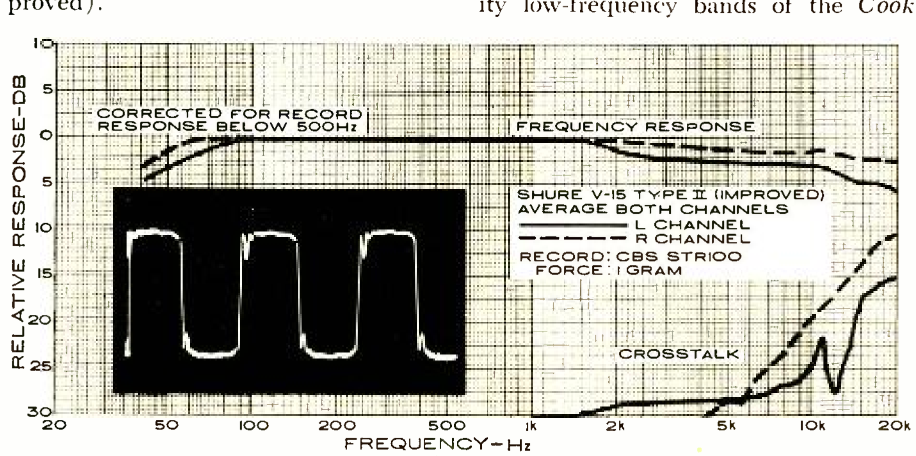
For copy of manufacturer's brochure, circle No. 2 on Reader Service Card.

THE highly regarded *Shure* V-15 Type II stereo phono cartridge has undergone a further improvement, involving a new stylus assembly. The new stylus can be distinguished from the original type by the words "Super-Track" in red (it was black on the original V-15 Type II). With the new stylus, it is known as the V-15 Type II (Improved).

Basically, the improvement consists of higher tracking ability at middle and low frequencies. Below 1000 Hz, the new stylus can track velocities about 2-dB higher than the old one. The manufacturer rates its "trackability" at a maximum of 38 cm/s in the 800- to 1000-Hz region. From a listening standpoint, this affects its reproduction of piano, bassoon, double-bass, bass drum, and organ pedal notes, which can now be played at only 1-gram force. Formerly, some high-level passages required 1.25 to 1.5 grams for proper tracking.

The frequency response of the cartridge, measured with the *CBS Labs* STR100 record, was exceptionally flat, within ±1.5 dB on one channel and ±2.5 dB on the other, from 40 to 20,000 Hz. The slight peak at 15 kHz that we had found on the original V-15 Type II was gone—in fact, there were no major resonances occurring between 10 Hz and 20 kHz.

The cartridge tracked the high-velocity low-frequency bands of the *Cook*



stack these up against the others . . .

①

②

③

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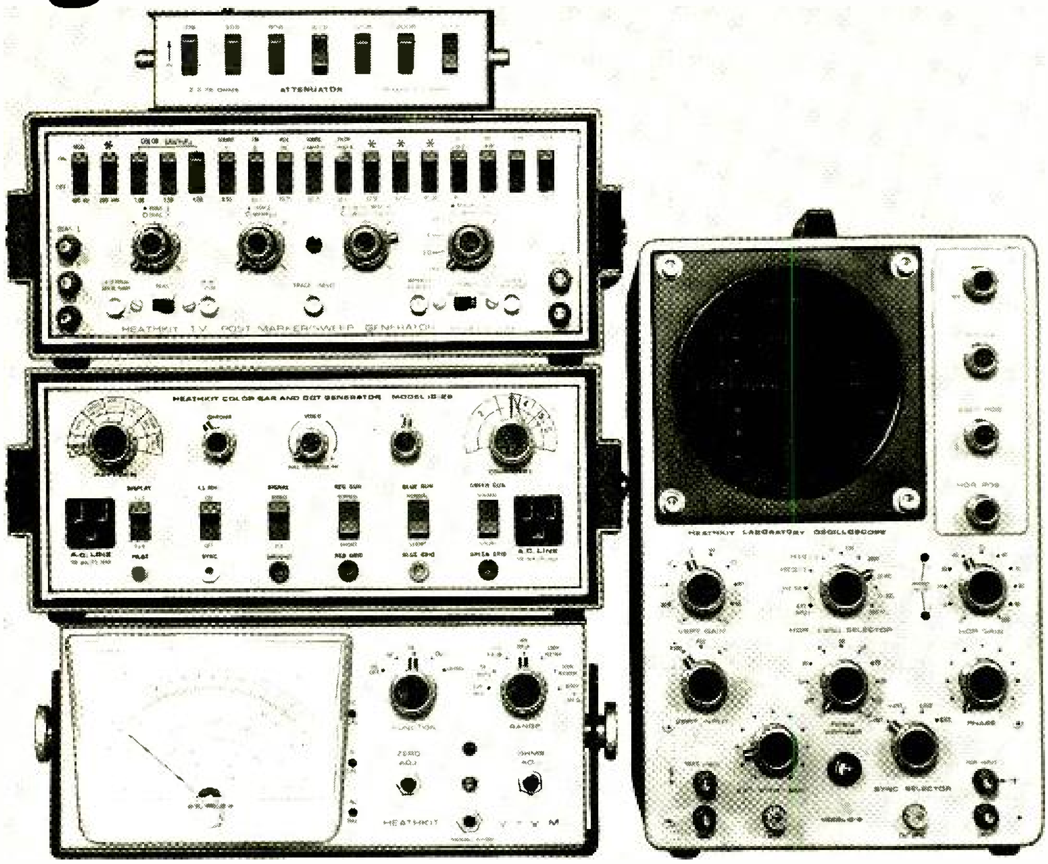

for just the price of other sweep-marker generators, you can get a bench full of Heathkit® color test gear

Stack These Up Against The Others . . . a high performance Sweep-Marker Generator, an accurate Color Bar-Pattern Generator, a versatile VTVM and a rugged, dependable Scope . . . all for only $347.40* . . . $50 *less* than the cost of other sweep-marker generators alone. At Heath, we still believe that you should be able to get a stack of gear without spending a pile of money.

① **Heathkit IG-57A Solid-State Sweep-Marker Generator . . . $135.00*.** 15 crystal controlled markers for color band-pass, TV sound, IF, picture & sound carriers for channels 4 & 10, FM IF . . . new Video Sweep Modulation allows injection of chroma-sweep directly into IF amplifiers or thru antenna terminals . . . two built-in variable bias supplies . . . 400 Hz modulated or CW output of any individual marker . . . exclusive external attenuator . . . stable, linear sweep signals for the five most used frequency ranges . . . complete scope matching controls . . . quick disconnect BNC connectors . . . complete with all probes, test leads & terminated cables. 14 lbs. Assembled IGW-57A, 11 lbs. . . . $199.00*

② **Heathkit IG-28 Solid-State Color Bar-Pattern Generator . . . $79.95*.** Produces 12 patterns plus clear raster . . . dots, cross-hatch, vertical & horizontal bars, color bars and shading bars in 9x9 or exclusive 3x3 display . . . all solid-state using computer-type integrated circuitry . . . variable front-panel tuning for channels 2 thru 6 . . . variable front-panel positive and negative video output . . . front panel negative going sync output . . . built-in gun shorting circuit with lead piercing connectors . . . switchable crystal-controlled sound carrier. 8 lbs. Assembled IGW-28, 8 lbs. . . . $114.95*

③ **Heathkit IM-28 "Service Bench" VTVM . . . $39.95*** Measures RMS DC & AC Volts from 1.5 — 1500 . . . AC P-P from 4 — 4000 V . . . resistance from 0.1 ohm — 1000 megohms . . . easy-to-read 6" meter . . . 10-turn vernier controls for zero & ohms . . . single test probe for all measurements . . . ±1 dB 25 Hz — 1 MHz response. 7 lbs. Assembled IMW-28, 7 lbs. . . . $59.95*

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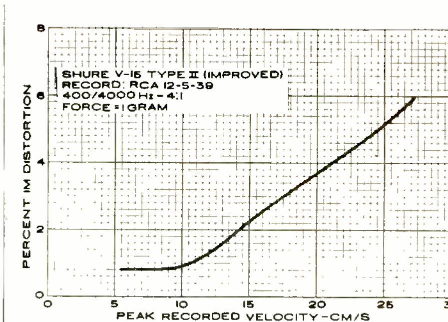
CIRCLE NO. 138 ON READER SERVICE CARD



Series 60 record at 0.75 gram, and the 30 cm/s 1000-Hz bands of the *Fairchild* 101 record at 1 gram. Although it is not the only cartridge we have tested which can do this, it is the only one to have no visible waveform distortion when playing the latter record. Its IM distortion, with the *RCA* 12-5-39 record, increased smoothly from less than 1% at 10 cm/s and below to a maximum of 6% at 27.1 cm/s, with no signs of mis-tracking or the sudden increase of distortion at high velocities that characterize many cartridges. The results at 0.75 gram were similar, but distortion was appreciably higher at high velocities, and we would prefer to operate the cartridge at 1 gram.

The tone-burst response of the cartridge when playing the STEREO REVIEW SR12 record was perfect up to just below 20 kHz, where it showed some irregularity. Channel separation was excellent, better than 30 dB up to about 5 kHz, 20 dB at 10 kHz, and 8 to 10 dB at 20 kHz.

Since the basic cartridge is unchanged, the excellent hum shielding has been retained. The new stylus produced about 3 dB more output than the old one, 3.7 millivolts at 3.54 cm/s. In our tracking-ability tests, using the *Shure* "Audio Obstacle Course" record, the improved model was perfect except for a slight mis-tracking of the highest level of orchestral bells. So far, no cartridge we have tested has succeeded in coping with that passage. The cartridge is, however, among the best we have tested to date when it comes to playing this record without distortion. It is audibly better than the original V-15 Type II phono cartridge on the piano sections of the record.

It is no surprise, in view of the test results, to find that the cartridge sounds outstandingly smooth and clean. It is completely neutral in character, with no emphasis of any portion of the spectrum. Its effortless and unstrained reproduction gives assurance to the user that any distortion he hears is in his records or elsewhere in his system—but almost certainly not in the cartridge.

The price of the *Shure* V-15 Type II (Improved) is unchanged at $67.50. Owners of older V-15 Type II cartridges can convert them to the latest version by installing the new stylus ($27.50), with the words "Super-Track" in red. ▲

3 New Action-Packed Kits From Heath

NEW Heathkit "Spectre" ⅛ Scale R/C Car
Join The Most Exciting New Hobby In America...

building and racing radio-controlled Grand Prix cars up to scale speeds of 200 mph. The Heathkit "Spectre" R/C car reaches that speed and has already proven itself a winner. And no wonder; its design is unique. It has a chrome plated steel chassis, adjustable caster and toe-in, specially formulated rubber tires that lock onto the cast nylon wheels, independent front suspension for excellent cornering and a 5.5:1 gear ratio for maximum torque at all speeds. The snap on, ⅛ scale car body (length: 19¾") is of high impact plastic — almost indestructable. Suspension is by real coil springs. The radio equipment compartment is dirt and oil proof. The Heathkit "Spectre" is the only complete car kit available. You get the body, chassis, wheels & tires, 4 oz. fuel tank & tubing, equipment case & protective foam, centrifugal clutch & gears, axles, servo linkages & mounting tape, all hardware, decals, numbers and a comprehensive manual. The "Spectre" accepts any .15 to .23 cubic inch R/C engine and any proportional R/C electronics system. It requires only two servos to operate the steering, brake and throttle. Get in on all the thrills of R/C car racing at the lowest possible price . . . order a Heathkit "Spectre".

Kit GD-101, R/C car only, 8 lbs.................................**$49.95***
Assembled GDA-101-1, Veco® .19 R/C engine, 1 lb...............**$19.95***

Heathkit GD-101
$49⁹⁵*

NEW Heathkit 3-Channel Digital Proportional R/C System
For Planes, Gliders, Cars And Boats

Ideal for use with the new Heathkit "Spectre" R/C car to give you total control . . . ease of handling. Here's what the Heathkit GD-57 R/C system includes: Transmitter with assembled, factory aligned RF circuitry; new 2 oz. miniature receiver that needs no IF alignment, in a tough nylon case; you also get two servos; all plugs; connectors; cables; charging cord; new flat-pack rechargeable nickel-cadmium transmitter and receiver batteries . . . and a special soldering iron. You can have your choice of five operating frequencies in each of three bands . . . 27, 53 or 72 MHz. This is the most value ever offered in a 3-channel rig.

Kit GD-57, transmitter, receiver, 2 servos, batteries, charging cord, switches and soldering iron, (specify freq. desired), 11 lbs.......**$129.95***
Kit GDA-57-1, transmitter, battery, charging cord, (specify freq. desired), 5 lbs...**$54.95***
Kit GDA-57-2, receiver only, (specify freq.), 1 lb...................**$34.95***

Transmitter

Heathkit GD-57
$129⁹⁵*

Receiver

Battery Pack

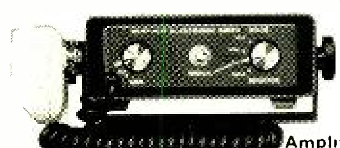
Servos

NEW Heathkit Siren/PA
For Licensed Emergency Vehicles Only

Hey Chief! Save up to 60% on a new electronic siren/PA system by ordering the low cost Heathkit GD-18. The siren gives both "wail" and "yelp" warnings at 55 watts output power, and you can adjust the pitch. As a public address it will amplify your voice with a full 20 watts of power, and it's practically immune to acoustical feedback. (Either PA or siren can be interrupted to use the other.) Incoming radio calls can be channeled through the GD-18 so you can hear them when away from your vehicle. Use it on any 12-volt auto electrical system with either positive or negative frame ground. It will operate from -20° to 150° F conditions. Control panel is lighted. Comes with gimbal bracket mounting. Take your choice of speakers . . . concealed or exposed.

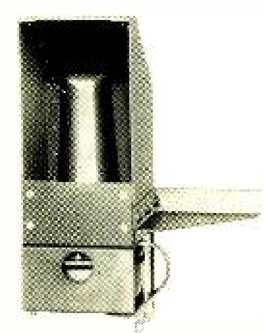
Kit GD-18, Siren/PA Amplifier, 7 lbs..............................**$54.95***
Assembled GDA-18-1, Exterior Horn, 9 lbs........................**$49.95***
Assembled GDA-18-2, Concealed Horn, 4½ x 4½ x 13", 9 lbs.....**$49.95***
System GD-18A, (includes GD-18 plus exterior horn), 16 lbs........**$99.95***
System GD-18B, (includes GD-18 plus concealed horn), 16 lbs....**$99.95***

Heathkit Siren & Speaker
$99⁹⁵*



Amplifier & Controls

Exterior Horn



Concealed Horn

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Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, guitar amplifiers, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

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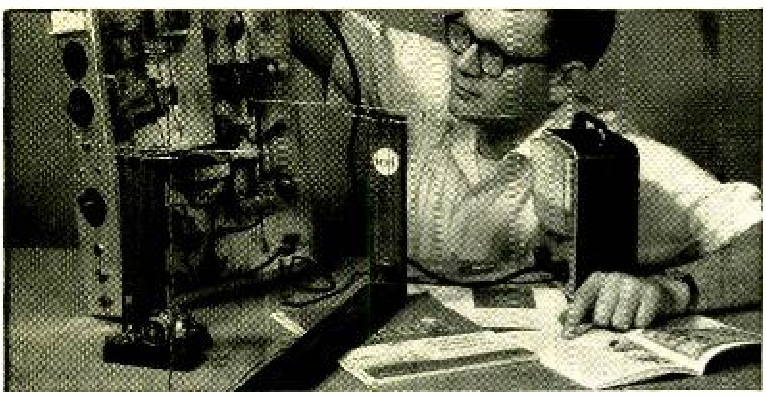
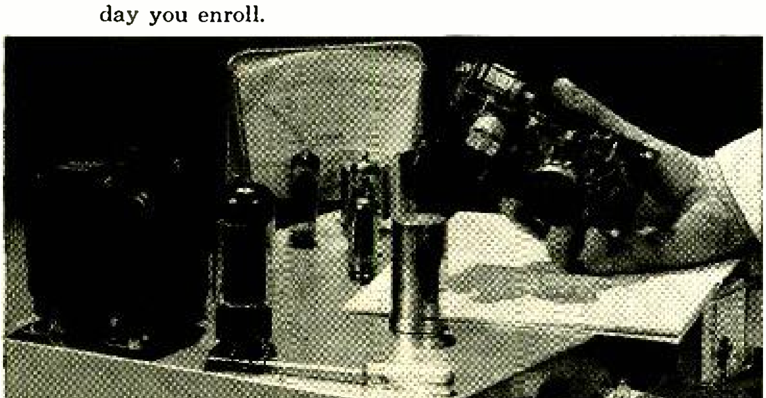
CIRCLE NO. 138 ON READER SERVICE CARD

Experience is still your best teacher

NRI Achievement Kit is educator-acclaimed and the original "starter" kit in home study training. Imitated but never duplicated, this kit is designed and personalized for you and your training objective. It has one purpose — to get you started quickly and easily.



"Bite-Size" Texts average an easily-digested 40 pages of well-illustrated, scientifically prepared subject matter in the course of your choice. Questions in each book are carefully hand-graded and returned to you with helpful instructional notes. You get unlimited personal help from the day you enroll.



Designed-For-Learning Equipment

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

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

Ask any teacher, job counselor, engineer, technician or prospective employer about the need for practical application of theory in Electronics. He'll tell you Electronics is as much a "hands-on" profession as dentistry or chemistry. That's how you learn at home with NRI. You prove the theory you read in "bite-size" texts, by actual experimentation with the type of solid-state, transistor and tube circuits you'll find on the job today — *not* hardware or hobby kits. You introduce circuit defects, analyze results, discover quickly the kind of trouble-shooting and design techniques that will make you employable in Electronics.

Train with the leader—NRI

NRI lab equipment is designed from chassis up for effective, fascinating training — not for entertainment. The fact that end results are usable, quality products is a bonus. In Communications, for example, you build and analyze, stage by stage, your own 25-watt phone/cw transmitter. It's suitable for use on the 80-meter amateur band, if you have an interest in ham radio. In TV-Radio Servicing your practical training gives you your choice of monochrome or color TV sets. All training equipment is included in the low tuition — you pay nothing extra. Discover for yourself the ease, excitement and *value* of NRI training. Mail postage-free card today for new NRI Catalog . . . or use the coupon below. No obligation. No salesman will call on you. NATIONAL RADIO INSTITUTE, Washington, D.C. 20016.

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ACCREDITED MEMBER NATIONAL HOME STUDY COUNCIL

NEW Show Set for Chicago

THIS year's 1970 NEW Show/Conference has been scheduled for May 11, 12, and 13 at Chicago's Hilton Hotel. Promising to be bigger and better than ever, with over 140 manufacturers represented, the Show will feature displays, product presentations, distributor/supplier conferences, national marketing seminars, the introduction of new products, new policies, and new packaging, as well as providing an ideal setting for sales meetings.

Admission is free to qualified members of the trade, including exhibitors, distributors, representatives, advertising agencies, export agencies, industrial buyers, and government personnel. Official badge forms are being distributed by the Electronic Industry Show Corporation, 100 South Wacker Drive, Chicago, Ill. 60606 and by exhibitors participating in the Show. A charge will be made for tickets obtained at the door.

The marketing seminars and technical programs provide for separate sessions for industrial/specialty distributors; general line/service dealer distributors; commercial sound contractors; and audio/hi-fi specialists. Each session will feature two speakers, one well known in the electronics industry and the other a leader in other industries with analogous problems. Such timely topics as "The Answer to Captive Service," "Solving Your People Problems," "Put Your Store Displays on Your Sales Force," will be thrashed out in depth by the experts.

Everyone in the electronics industry will gain by attending this unique Show. Meet the men with whom you do business, discuss your particular problems with the experts, and see what the manufacturers are planning in the way of new merchandise and services for the coming Fall selling season. See you at the Show. ▲

MANUFACTURERS REPRESENTED AT THE NEW SHOW

ATR Electronics
Acoustone
Aerovox
All Channel Products
All Tapes
Alpha Wire
Alliance Mfg.
American Geloso
Amperex
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Antenna Designs
Antenna Specialists
Antronic Corp.
Argos Products
Arrow, Hart, Inc.
Astatic Corp.
Atlas Sound Division
Avanti R & D
BSR (USA) Ltd.
Belden Corp.
Birnbach Co.
Blonder-Tongue
Bogen Division
Bowman Leisure Ind.
British Industries
Bud Radio
Burgess Battery
Bussman Mfg. Div.
C/P Corp.
Centralab Div.
Chambron
Chicago Miniature Lamp
Cinch Distributor Div.
Columbia Electronic Cables
Component Specialties
Consolidated Merchandising
Consolidated Wire & Assoc.
Carl Cordover & Co.
Cornell-Dubilier Electronics
Courier Communications
Curtis Electro Lighting
Dearborn Wire & Cable
Dynascan Corp.
Eico Electronic Instrument
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Essex International
Fanon Electronics
Fen-Tone Corp.
Fidelitone, Inc.
Finney Co.
GC Electronics
Game Industries
Gardiner Solder Co.
General Electric
Grayhill, Inc.
Hallicrafters Co.
Heeger, Inc.
Hi-Tron Semiconductor
IE Manufacturing
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International Rectifier
International Wire & Cable
Irish Magnetic Tape
J-B-T Instruments
JFD Electronics Distributor Div.
JFD Electronics Systems Div.
Jensen Manufacturing
Jerrold Electronics
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Leader Instruments
Lectrotech, Inc.
Linear Systems, Inc.
Littelfuse, Inc.
Lowell Mfg. Co.
Lykes Electro/Thoro Test Div.
Magitran Co.
Mallory Distributor Prod.
Memcor Div.
Midland International Corp.
J. W. Miller Co.
M. A. Miller Mfg. Co.
Mura Corp.
North American Electronics
Oak Manufacturing
Ohmite Corp.
On-Guard Corp. of America
Oxford Speaker Co.
Pace Communications
Philmore Mfg. Co., Inc.
Potter & Brumfield
Quam-Nichols Co.
RCA Electronic Comp.
RCA Parts & Accessories
RMS Electronics
Radatron Corp.
Recoton Corp.
Robins Electronics
Rohn Manufacturing
Russell Industries
S & A Electronics
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Semitronics Corp.
Sencore, Inc.
Shure Brothers
Simpson Electric
Herman H. Smith, Inc.
South River Metal Products
Soundolier, Inc.
Sprague Products Co.
Switchcraft, Inc.
Sylvania Electronic Products
TRW Distributor Products
Ten-Tec, Inc.
Terado Corp.
Thomas & Betts Co.
Tram Corp.
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Triplett Corp.
Trutone Electronics
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Vaco Products
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Vikoa, Inc.
Waldom Electronics
Weller Electric Corp.
Weltron Co.
Winegard Co.
Worner Electronic Devices
Workman Electronic Products
Xcelite, Inc.
Zenith Sales Company
(as of Dec. 31, 1969)

By FOREST H. BELT/Contributing Editor

Business as Usual (?) at EIA

Not all dramas are on the stage. One played itself through in our industry not long ago. George Butler, energetic new president of the Electronic Industries Association, relieved Jack Wayman, staff vice-president and efficient ramrod of the consumer products division, of his duties. The ensuing objections threatened to split the organization. Would Wayman's division pull out and form a separate association?

It might have. But the rift has been healed—if somewhat forcibly—by EIA's board of directors and Wayman was rehired. The final act isn't written, but things are simmering quietly for now.

One apt comment came from Dick Glass, executive VP of National Electronic Associations. He reminded EIA of the many times its members have chided the servicing industry for its internal squabbles. Looks like the shoe is on the other foot. EIA can no longer use that as a reason it "can't" endorse publicly the service-industry programs it privately applauds.

Meanwhile, plans go ahead for upgrading vocational electronics instructors at seminars this summer. Seminars will be held at Iowa State University (at Waterloo), Bemidji (Minnesota) State College, City University of New York (at Hartsdale), East Tennessee State University (at Johnson City), and Los Angeles Valley College (at Van Nuys). For dates write EIA, 2001 Eye St. N. W., Washington, D. C. 20006.

EIA is also countering a whole raft of regulatory problems. The FCC demands tuner parity ("U/V Tuners to Tune Alike," page 13, April, 1970 issue) sooner than set-makers can accomplish it properly. EIA says it would be better to wait for electronic tuning, which could do the job right. That's not far off, but the FCC deadline is too soon for it.

Another problem is the sales-reporting requirement under the new Radiation Act. There's a heavy burden on distributors and dealers. Manufacturers, through EIA, recommended the rules be altered to exclude color sets that can't emit radiation. Sets with solid-state rectifiers and regulators, and whose CRT's have strontium-carbonate faceplates, can't put out enough x-rays to even measure.

Service-Business Paradox

RCA Service Co. is expected to start servicing other brands. The new nationwide service outfit might go under a different name, and work from different shops. But it would be staffed, says the grapevine, by employees drawn from *RCA Service Co.* facilities. It isn't widely discussed, but they have serviced "outside" brands for years, when those sets are part of a group under maintenance contract at a motel, hotel, or hospital.

What makes this step interesting is the trend of independent servicers in the opposite direction. Some of the most successful TV shops are becoming one-brand businesses. Frequently, the chosen brand is whatever the shop sells. But quite a few service-only companies prefer to handle a single brand. With a half-dozen brands very popular, there are plenty of customers. Parts inventory is simplified. Keeping up with new models and production changes is easier. And there is a bonus in familiarity.

This trend makes it hard for owners of less popular brands and imports, but that's what is happening. If the advantages appear to lie in one-brand specializing, we can't help wondering what *RCA Service Co.* knows that the independents don't.

Public Hi-Fi Exhibit in NYC

A group of stereo-component manufacturers and audio-magazine publishers are setting up a video/audio showroom in Manhattan. It is to be called Sound Electronics Exhibits, or SEE 70. Opening is scheduled in late April. Publicity and advertising are planned to attract people visiting the city as well as natives of New York and suburbs. There are about two dozen exhibitors, and radio station WRFM will broadcast live from the showroom. Promoters of SEE 70 feel it will serve the industry and the public much more effectively than a five-day show once—or even twice—a year.

Leasing Catches On

The idea of leasing TV sets ("Franchised TV Leasing," page 6, March, 1970 issue) is spreading. *Tele-*

Quick, a small Midwestern firm that franchises TV repair centers. is adding a leasing operation. The sets will be made by *Philco-Ford* and leased through regular *Tele-Quick* stores. As seems always the case with TV-leasing schemes, parts and maintenance are included in the monthly rental fee.

Another, a nationwide product-leasing concern has publicized plans to rent large numbers of TV sets to colleges and universities, which rent them to students during the semesters. The company has done this successfully with portable refrigerators for almost two years.

Police and Taxi Calls on TV

If u.h.f. viewers are really going to have their programs disrupted by two-way radio calls. as broadcasters predict they will, it'll start happening pretty soon. More and more, it looks as if the FCC is shortly going to approve sharing a few channels at the bottom of the u.h.f. TV band. It will start as experimental. But if the interference problem doesn't materialize, the allocation will probably become permanent.

It is on a shared basis. But the decision that favors such sharing is an open door to similar sharing at other TV frequencies. If the trend continues, the next step is of course for land-mobile two-way to take over certain u.h.f. channels exclusively. Carried to its ultimate possibility, it could eliminate TV on these bands. And that naturally moves our whole TV system closer toward cable distribution—perhaps without even using u.h.f. and v.h.f. carriers. That's an eventuality the FCC should weigh seriously in deciding just how to solve the very real land-mobile crowding problem.

Repairs for Imports

In the February column we recounted how hard it is for customers and technicians to get information and parts for imported TV sets. (We assume the problem applied to other imported home-entertainment equipment. too.) We even offered to tell our readers about any importer who (1) cooperates with independent servicers who try to service that brand, (2) has parts available quickly and without extensive red tape, (3) has a system (that works) by which a buyer of that brand can get prompt and dependable service when needed.

So far, the importers who have contacted us offered only excuses why their systems don't work—and we've developed some notions of our own as to why. We're still waiting for that ideal importer to come forward and identify himself. In the meantime, we'd like to hear from readers exactly what problems you have with importers. Send names, dates, and only verifiable facts, please, to ELECTRONICS WORLD.

Business Booster

Sometimes operators of small consumer electronics businesses run out of ideas. They may want to expand. or they may need to replace lost business. Here's a business-building idea that has worked for a couple of service dealers.

Find a department store that is roomy and sells home-entertainment electronics. Very often, these days. such stores can't offer good service to their electronics customers—even though many of them would like to. Talk the store management into providing space and a counter where you can install "their own" in-store service department.

The secret is, your technician there does only whatever work he might do on a home service call: tube, transistor, or fuse replacement; minor wiring or knob repairs; portable antenna replacement; etc. A self-service tube tester sells a lot of tubes to the brown-bag customer. A stock of batteries for portable radios, with a fee if your technician installs them, takes care of that angle. Phono needles and cartridges are easy to install. again for a fee.

Sets that need major repairs are checked in, a claim check is given. and the day's sets hauled to the main shop every evening and put into the regular bench-servicing lineup. You get a lot more customers. the store gets something that attracts new-set prospects by the droves. and the customers have a convenient place to drop off the bad set while they run other shopping errands.

(P. S. If you've got an idea that built up your business and you'd like to share it. send details to ELECTRONICS WORLD.)

Flashes in the Big Picture

CBS Labs tells of new electronic unit (available to broadcasters at close to $3000) that corrects phase errors at any point along colorcast transmission chain: if it works as described, variations in face color from camera to camera to film to commercial. etc. should be eliminated. . . . Japan firms are cooperating to develop all-IC color TV. same as they are on all-IC stereo-FM set (which hasn't appeared yet). ▲

NEWS HIGHLIGHTS

Engineering Crisis

If Purdue University's School of Engineering can be used as a barometer to estimate engineering manpower in near future, then the United States may be in for a lot of problems —engineering-wise. Indications point to leveling off in number of engineers produced by colleges and universities despite fact that over-all population will continue to increase. Defense cutbacks with accompanying engineering layoffs and youths' zealous interest in society's social and environmental problems combine to establish an anti-engineering atmosphere for the young of our country. Seems as though it's up to engineering schools to do exceptional public relations jobs in informing youth that the solution to these very problems require technological know-how of dedicated engineers—and, we might add, that engineering schools strive to bring their curricula up to date to reflect type of engineering services our nation will need to face future with confidence.

Insurance for Insurance Companies

The opening of a Biomedical Screening Center, first of ten such centers planned for Greater New York Area, was announced recently by *Biometric Systems, Inc.* Specifically geared for physical examination of insurance applicants, the latest in medical electronic instruments will be used to provide rapid (15 minutes) and accurate paramedical tests and to assure fast, reliable analytical data feedback to insurance company for final evaluation. Where practical, computers will perform all routine work (e. g., analysis of EKG waveform data) freeing physicians and technicians to concentrate on the medical problems requiring human competence.

Capacitor Standards

The Engineering Department Group of the Electronic Industries Association is looking for those interested in working on development of an industry standard for oil paper-dielectric capacitors with a.c. voltage ratings. Object of new standard is to reduce the number of variables in products of similar rating and define acceptable performance characteristics and requirements as well as identifying readily available standard types. Ratings, sizes, measurements, and test requirements for such capacitors now used in motor running, lighting, ferro-resonant transformer power supplies, etc. will be covered. Interested parties should contact William M. Robinson at *Cornell-Dubilier Electronics,* 1605 Rodney French Blvd., New Bedford, Mass. 02741.

War on Pollution

With Administration officially declaring war on pollution (specifically water and air), the need for effective pollution control instruments becomes more pressing. In an attempt to meet this need, *Barringer Research* of Toronto, Canada has introduced a new mobile system that can measure concentration of noxious gases present in the atmosphere and simultaneously identify culprit. Called a Correlation Spectrometer, it can be placed in a vehicle and driven along a planned route of investigation to identify, measure, and record level of pollutants present. Working on principle that each chemical absorbs, emits, or reflects basic electromagnetic units (photons) with distinctive patterns, a telescope in the unit "looks" through the "suspect" air and picks up scattered sunlight. This light is dispersed by a grating against a mask which has engraved upon it the characteristic spectrum or signature of particular gaseous molecules under investigation and measures the amount of light to determine quantity of air contaminant. Nitrogen dioxide and sulfur dioxide masks are presently available. Masks for carbon monoxide, ozone, certain hydrocarbons, and other gases of interest are being developed . . . and along these same lines Aerospace Systems Div. of *Bendix Aerospace-Electronics Co.* has developed an infrared spectrometer-computer system for detection and measurement of both ozone and sulfur dioxide air pollutants. Cognizant of the fact that these pollutants absorb radiation at certain known wavelengths, a beam of infrared radiation is transmitted through the atmosphere to a receiver. The computer uses the digitally integrated signals from the wavelengths selected for examination to calculate a weighted sum which is proportional to the concentration of each pollutant in the air. Every 2 milliseconds computer generates a bar-chart display of the most recently completed infrared spectral scan as well as the computed amount of each pollutant. Two of these units have been built and a third is being constructed for the National Air Pollution Control Administration of the U.S. Public Health Service.

Radar Road Map

A radar system built by *Philco-Ford Corporation's* Aeronutronic Div. literally hand-led world's first commercial tanker-icebreaker, the SS Manhattan, through Northwest Passage. Carried aboard a Coast Guard C-130 ice-reconnaissance aircraft, the side-looking airborne radar system scans an area 10 miles wide and generates a strip map which is recorded on film. Film is then parachuted to ship for developing and analysis. Processed film acts as a "sea road map" by showing ice floes, pressure ridges, breaks in ice, and open water, thereby permitting ship to select safest access route. Cmdr. Robert C. Powell, project officer of Office of Research and Development, Coast Guard Headquarters, Washington, D.C., said that this radar had proved highly effective in determining ice conditions by day and night, through clouds, darkness and fog, and that "detailed photographs provided through this side-looking radar could be a great boon in lessening the ice hazard to shipping."

New IC Technique

New fabrication technique developed at *Bell Telephone Labs* permits design of integrated circuits smaller than a grain of sugar. Performance compares favorably with MOS IC's now in use and promises to be more economical to make. Uses only 3 photolithographic masking steps as opposed to usual 5 to 7 steps required to fabricate conventional bipolar transistor IC's and yet displays same low, sharp, and stable threshold values. Based on formation of lateral transistors (transistors in which injected carriers flow parallel to surface rather than perpendicular to it), tri-mask (TRIM) technique permits collectors and emitters to be diffused simultaneously and results in formation of a high proportion of functioning circuits as well as simplicity of fabrication. TRIM technology has been used by the *Labs* to build computer and telephone switching IC logic circuits.

Renting Test Equipment

Being ever-so-aware of insidious inflation that exists and belt-tightening psychology that is sure to come, *Telonic Industries, Inc.* of Laguna Beach, California recently announced establishment of a unique proprietary test-equipment leasing program. Attractive part of this program is that the most modern test equipment will be available without capital investment. Typically, one of *Telonic's* most expensive test instruments, which normally sells for $6400, will be available for as little as $165/month under new plan.

New Rechargeable Battery

A titanium-grid, lead-acid rechargeable battery, smaller and lighter than conventional storage batteries has been developed by Dr. Samuel Ruben for *ESB Incorporated* of Philadelphia, Pa. Only drawback is titanium's high cost as opposed to lead, which will initially limit its use to applications where space saving, weight, or high-energy performance are prime factors. Some areas where this type of power source could find greatest use are in portable television sets, power tools, camping equipment, and other cordless devices, and ultimately in powering tomorrow's electric vehicles.

Like Father—Like Son

On March 11, Robert W. Galvin, Chairman of the Board and Chief Executive Officer of *Motorola Inc.*, received the electronic industry's most coveted award, the EIA Medal of Honor, at the Annual Government-Industry Award Dinner of the Electronic Industries Association in Washington. As the 19th recipient of the award, this places him in the company of such prestigious personalities as his father, Paul V. Galvin, founder of *Motorola*, and David Sarnoff, Honorary Chairman of the Board of *RCA*. Mr. Galvin began his electronic career at *Motorola* in 1944, became executive vice-president in 1948, president in 1956, and was elected to his present position in 1964.

Aid For Handicapped

Fairchild Controls, a division of *Fairchild Camera and Instrument Corporation*, has developed a breath switch control device to aid those who are incapacitated. Called the *Fairchild* Breath Switch Control, it consists of two PSF100A pressure switches and a solid-state d.c. relay with power input and external control terminals. Requires only puff of air to actuate. Handicapped person (paraplegics, stroke victims, bedridden patients, or anyone unable to use hands) blows into a funnel on right side of unit to activate the control. A puff of air into the funnel at the left side will shut off the phone or other controlled device. Inexpensive and small in size, this device can be used with telephones, intercoms, alarms, motorized wheelchairs, and other similar equipment.

Coming Events

This year the NEW (National Electronic Week) Show will be held at the Hilton in Chicago, May 11-13. For information concerning highlights of the NEW Show, see page 16 of this issue. . . . On May 13-15, the 20th Electronic Components Conference will be held at the Statler-Hilton in Washington, D.C. where some 90 papers will be presented. . . . Immediately following this Conference, from May 18-30, and in the same locale, the 35th International Electrotechnical Conference, made up of representatives of 41 countries (some 1500 delegates) will be held. The development of international standards on symbols, definitions, test methods, performance, and dimensional requirements in the areas of electronics, telecommunications, power generators, power transmission, power distributors, industrial equipment, consumer goods, and medical equipment will be discussed. . . . And, on June 16-18, once again in same locale, the IEEE's 4th Annual Computer Group Conference and Trade Show for designers and manufacturers of peripheral equipment will be held. Over 60 foreign and domestic exhibitors, covering the range of peripherals and memories, have reserved space at the time of this writing. The combination of hottest technical topic of year (peripheral market predicted to be twice that of computer mainframe in the 1970's), presence of those most important in this field, and a carefully balanced technical program augurs well for the success of this show. ▲

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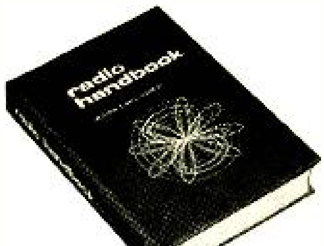

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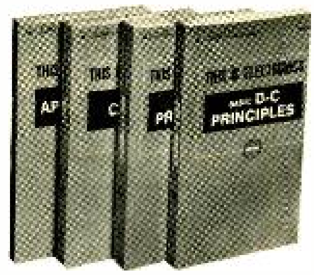

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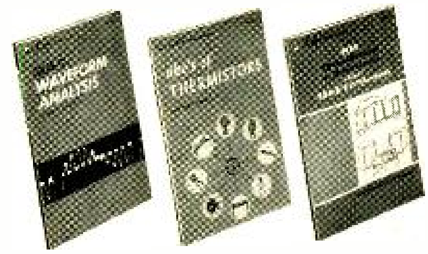

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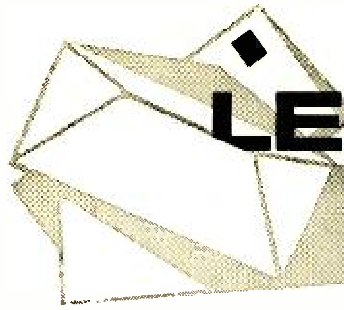


LETTERS

SETCHELL CARLSON TV

To the Editors:

In the article "Color TV for 1970" in the February, 1970 issue of ELECTRONICS WORLD, you point out several highlights of current receivers. We realize it must be difficult to be aware of all receivers on the market, and we therefore would like to bring to your attention *Setchell Carlson*.

Unfortunately, *Setchell Carlson* has discontinued the manufacture of domestic receivers and has concentrated and expanded its production exclusively into the professional and educational areas. Nevertheless, we should like to mention that the company has always used and pioneered the idea of unitized construction and has used epoxy-glass boards since early 1968 in its color portables and, last year, in its 25-in models. This was solid-state except for 8 tubes and this chassis is now used in its monitor/receivers and for schools.

The company has had on the market for over a year now a 100% solid-state 25-in receiver using silicon controlled rectifiers (SCR's) in the horizontal-deflection circuit. You have mentioned in your article that *RCA* was the only one that has done this. You also drew attention to Canadian *Clairtone* using epoxy-glass boards, and again we draw your attention to *Setchell Carlson's* well-established claim to this area.

GEORGE KUSHNER
GW Colortronics Ltd.
Swift Current, Sask.

We were aware of the company's early work in modular or unitized construction. Since they are not a major factor in the domestic market, they were omitted from our article.—Editors

* * *

FM STEREO OR STEREO FM

To the Editors:

Referring to Mr. Philip N. Bridges' letter (November issue) concerning impropriety of the term "FM stereo," you suggested that perhaps the reason many broadcasters preferred to say "FM stereo" was to inform listeners we were not using the old system of FM/AM stereo, which was discontinued a decade ago when FM stereo began.

We might suggest two reasons why broadcasters say "FM stereo." First, for an announcer it is just somehow easier to say "FM stereo" than "stereo FM." Second, FCC regulations require that radio broadcasting stations announce their call letters and city each half-hour. Some FM stations do not carry "FM" in their call letters (that is, have four call letters rather than six) and so could legally say "stereo FM" following their call letters if they chose to. However, those of us who have six-letter calls, as KRMG-FM for example, must say those six letters in order. Thus, we are compelled to say "KRMG-FM stereo" to comply with Federal regulations. Perhaps it's true, as English teachers have claimed for years, that radio is corrupting the native language. But we'd like to keep our licenses to broadcast and, faced with the choice of violating the language or else violating the law, most of us will more readily plead guilty to the former charge.

DENNIS C. BROWN,
Oper. Dir., KRMG-FM
Tulsa, Okla.

Maybe Reader Brown can satisfy both the FCC and the grammarian by announcing "KRMG-FM, stereo FM."—Editors

* * *

ELECTRONICS & PLANTS

To the Editors:

Congratulations for the good and stimulating coverage of "Electronics & The Living Plant (October issue). This type of reporting on this type of subject is bridging a wide gap between the pedantically closed scientific mind and the healthy inquiring scientific mind.

Next time, however, there should be name credit, at least, given to the late George de la Warr, founder of the *De la Warr Laboratories* in Oxford, England. He spent much of his engineering-fostered career in a frustrating attempt to interest scientists in the repeatable experiments he and his staff were doing with plants. Also, Prof. Burr, *et al*, of Yale University—in the 30's yet!

E. D. TAMMINGA
Santa Fe Springs, Cal.

See also Fred Shunaman's letter on this subject last month.—Editors

* * *

MICROSTRIPLINE PARAMETERS

To the Editors:

With reference to "Microstripline Parameters" by Leon Sales (January, 1970), it appears that Fig. 3 and a resulting sample calculation are in error. The ratio represented on the vertical axis is equal to λ/λ_{TEM} only in the case of an air dielectric. In the case where $\varepsilon_r \neq 1$, a correction of $\sqrt{\varepsilon_r}$ must be applied. Thus, in the sample calculation, for a characteristic impedance of 50 ohms, $\lambda/\lambda_{TEM} = 1.23/\sqrt{\varepsilon_r} = 1.23/3.19 = .385$ and the quarter wavelength in the dielectric is actually $\lambda/4 = 2.5 \times .385 = .963$ cm.

BERNARD GELLER
Electromagnetic Technology Lab.
Westinghouse Electric Corp.
Baltimore, Md.

The error was the author's. Obviously in a non-air medium the wavelength of a line would be physically shorter than its free-space wavelength.—Editors

* * *

REGULATED POWER SUPPLIES

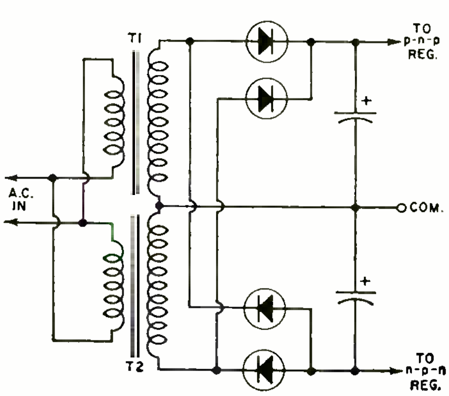
To the Editors:

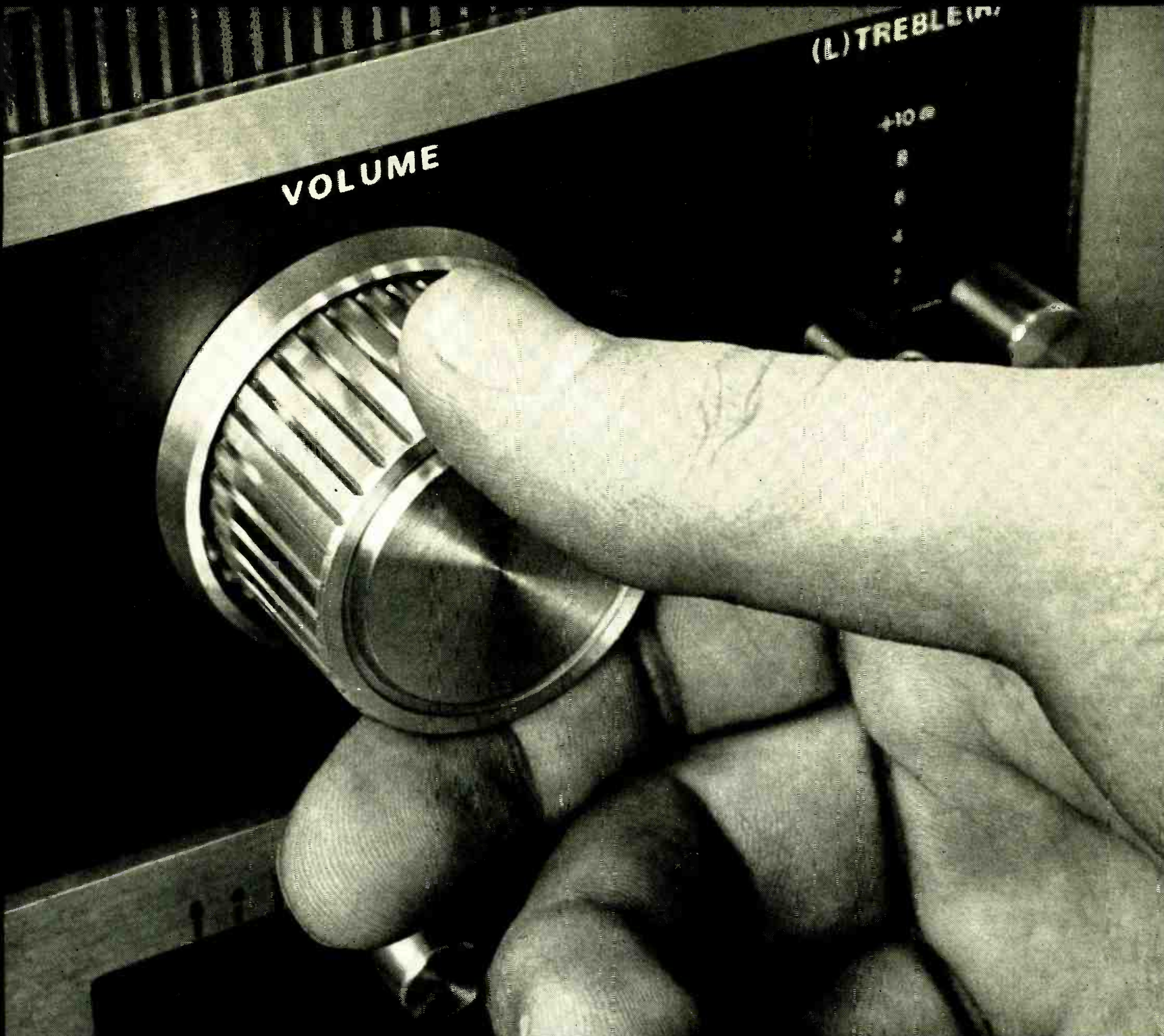
On page 33 of the February, 1970 issue ("Design and Construction of Regulated Power Supplies"), there is shown a dual-polarity power supply. It seems to me that the power transformer in the diagram is operating short-circuited. The innermost four rectifiers comprise a bridge with shorted output.

This problem can be eliminated by either of two methods: (1) Use two separate transformers with a bridge rectifier on each, or (2) use one center-tapped transformer with twice the voltage rating along with a single bridge.

RALPH PROUD
Somerset, N. J.

According to the author, the voltage across the two reservoir capacitors reverse-biases the diodes and prevents them from shorting the transformer. The use of a high-resistance transformer will also limit current through the diodes, while separate "Com" leads will remove the possibility of shorts. However, several of our readers have breadboarded the circuit in Fig. 7 and have found that a low-resistance path does in fact exist across the transformer; hence, we do not recommend the circuit shown in the article. This circuit, using two identical 10-V transformers or a single centertapped 20-V transformer, should be used instead.—Editors ▲





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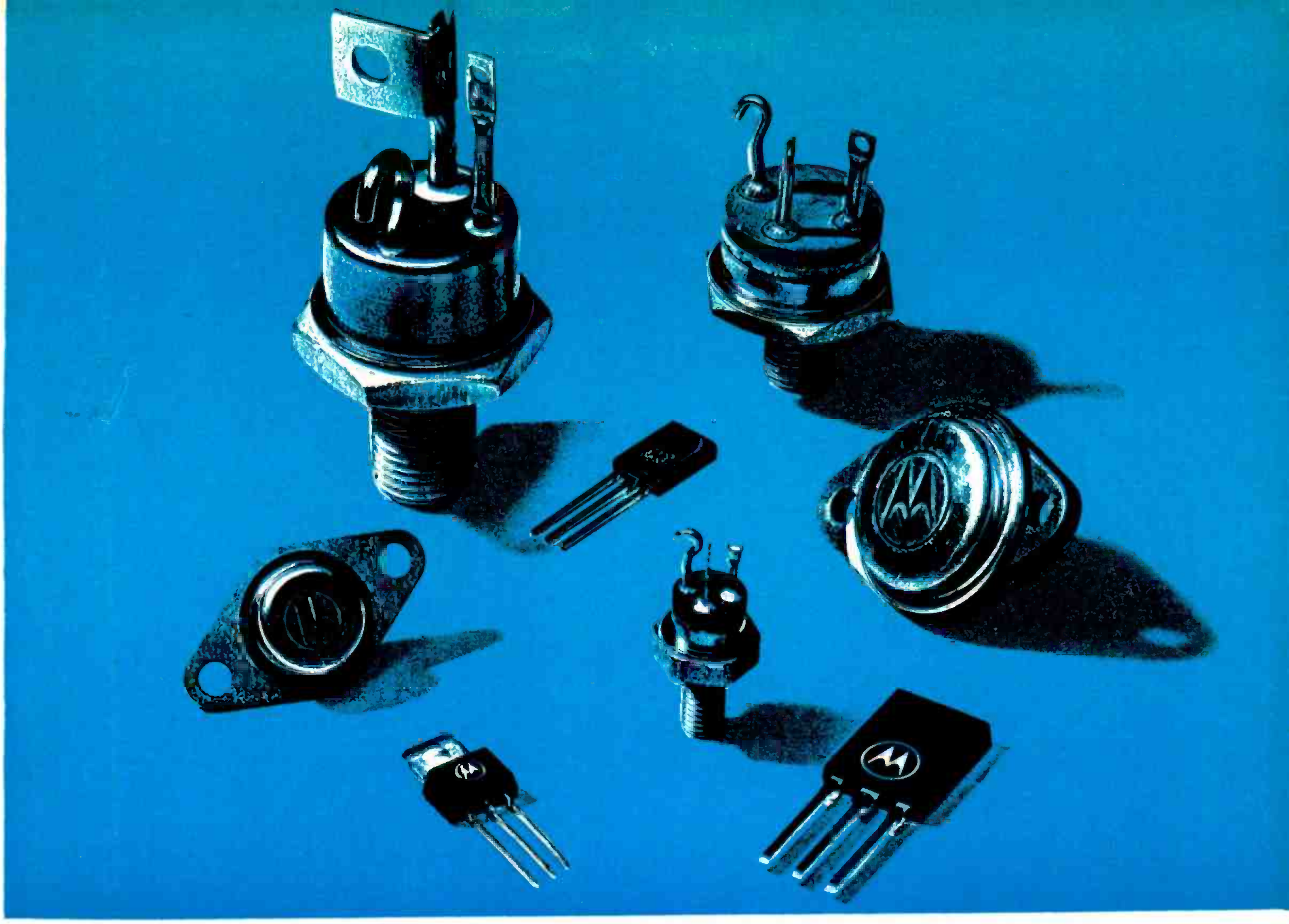


These are popular cases used for power transistors. Clockwise from the 1 o'clock position are: a 7/8-in isolated stud-mounted type used for high-reliability applications; the popular TO-3 case; case 90, Thermopad plastic package; small stud-mounted transistor case; Uniwatt plastic package; the TO-66 case; a 1 1/8-in stud-mounted transistor rated at 110 amperes; and case 77, a plastic-case design to replace the TO-66. Various other cases are also used.

POWER TRANSISTORS
—a Status Report

By PAUL FRANSON/Motorola Semiconductor Products Inc. (Presently with Teradyne, Inc.)

What's available now and what can we expect in the future? Improvements in production technique, in die design, and in packaging have resulted in better products and lower costs.

MUCH has happened in the past few years to power transistors. More innovation is expected in the future as the devices resulting from current research and development come into full production. Improvements in production techniques, in die design, and in packaging all result in lower costs and better products: annular power devices, higher voltage and current ratings, greater safe areas, and even power integrated circuits. Let's take a look at the field of power transistors and see what is available now and what we can expect in the future.

Present transistors have displaced low-frequency vacuum tubes because of their smaller size, greater mechanical ruggedness, higher efficiency, and other characteristics. They are also challenging electromechanical devices, such as mechanical relays and switches, for similar reasons. Among the reasons for this growth in the use of power transistors are the continuing rises in transistor voltage and current ratings and, of course, falling prices.

For example, transistors now available can operate at voltages as high as 1400 V for TV horizontal-deflection purposes, while others can handle up to 250 A at lower voltages for very heavy-duty power sources. High-power complementary pairs have revolutionized audio design. These are able to develop 200 watts of high-fidelity output while obviating the need for an output transformer which, at these power levels, would strain the budget of even the most affluent audiophile. New Darlington-connected power transistors, combining driver and output stages in a single package, will

PARAMETER IMPROVEMENT	PROCESS CHANGE	PARAMETER CHANGE
Breakdown voltage (BV_{CEO}) up	Base width up Resistivity up	SOA up (improvement) Gain down Saturation voltages up
Current gain (h_{FE}) up	Base width down Chip size up Resistivity down	Saturation voltages down (improvement) SOA down
Safe operating area (SOA) up	Base width up Chip size up Resistivity up	V_{CEO} up (improvement) h_{FE} down Saturation voltages up
Switching time up	Base width down Resistivity down	h_{FE} up (improvement) SOA down V_{CEO} down
Top frequency (f_T*) up	Base width down Collector thickness down	h_{FE} up (improvement) V_{CEO} down SOA down

*Higher f_T is not always desirable; it can lead to parasitic oscillation.

Table 1. Parameter trade-offs in epitaxial-base silicon power transistors. The process changes needed to effect the parameter improvement desired are shown along with the other parameter changes.

result in further circuit and equipment simplification in the years ahead.

Yet in spite of the exotic developments in power transistors, they remain excellent buys. In a world where inflation seems inevitable in most products, prices of transistors have dropped steadily, largely as a result of innovations and improvements in production techniques. While some power transistors are admittedly expensive in an absolute sense (if not in terms of their function or characteristics), more plebeian types sell for less than 50 cents in manufacturing quantities.

Power-Transistor Varieties

Modern processing technology provides the manufacturer with extensive control over each of the power-transistor electrical characteristics. This does not mean, of course, that we are about to see the "ultimate" transistor. It is a fact of semiconductor life that changing a process to optimize one parameter usually affects other parameters as well, often in an adverse direction. It does mean that transistors can be manufactured to fulfill specific requirements by maximizing the characteristics for that particular application at the expense of less important parameters. For example, one can easily increase the breakdown voltage of a device by increasing collector resistivity. By doing so, however, collector-saturation voltage is increased. Table 1 illustrates some of the major interrelations and trade-offs between performance parameters in popular epitaxial-base silicon power transistors.

Transistor characteristics are often determined not by processing details, but by the choice of the basic manufacturing process itself. Many years ago, for example, all power transistors were made by the alloy process. Today, while most germanium power transistors are alloy devices, few silicon transistors are. Alloy transistors are very rugged electrically and mechanically, but have relatively poor frequency response. And in silicon, they have low gain and low

Table 2. Characteristics of various types of power transistors along with applications and typical examples.

	P-n-p	N-p-n	f_T (MHz)	Ruggedness, SOA	Volts (max) (V)	Current (max) (A)	Cost	Major Applications	Examples
GERMANIUM									
Alloy	x		0.1	Good	60	60	Low	General	2N3618, 2N4276
Alloy-diffused epitaxial (ADE)	x		1	Fair	300	60	Medium	High voltage	2N5435, MP2400A
Post-alloy diffused (PADT)	x		10	Fair	300	20	Medium	Switching	2N2834, MP3731
SILICON									
Alloy		x	0.1	Excellent	300		High	Obsolescent	
Alloy-diffused		x	1	Good	60		Medium	"	
Single diffused		x	1	Excellent	140	30	Low	Power-supply regulator	2N3773
Hybrid single diffused (Annular version also available)		x	2	Good	140	20	Medium	General	2N4629-31, 2N5632-34
Double diffused annular	x	x	60	Low	100	100	High	Power switch	2N1724
Triple diffused (mesa)		x	4	Moderate	1500	5	Med-high	Auto ignition and TV deflection	MJ8401, MJ413, 423, 431
Triple diffused (passivated)	x	x	30	Moderate	350	50	Med-high	Line-operated audio output	2N3738, 39, MJE340
Epitaxial base (Annular version also available)	x	x	6	Good	120	50	Low	Complementary audio	2N3713-16, 2N3789-92, 2N4398 2N5301-3

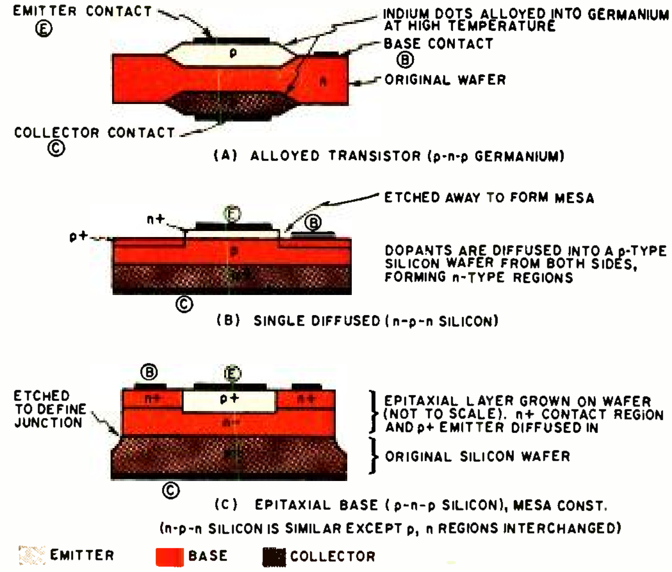


Fig. 1. Cross-sections of (A) alloyed, (B) single-diffused, and (C) epitaxial-base, mesa-construction transistor types.

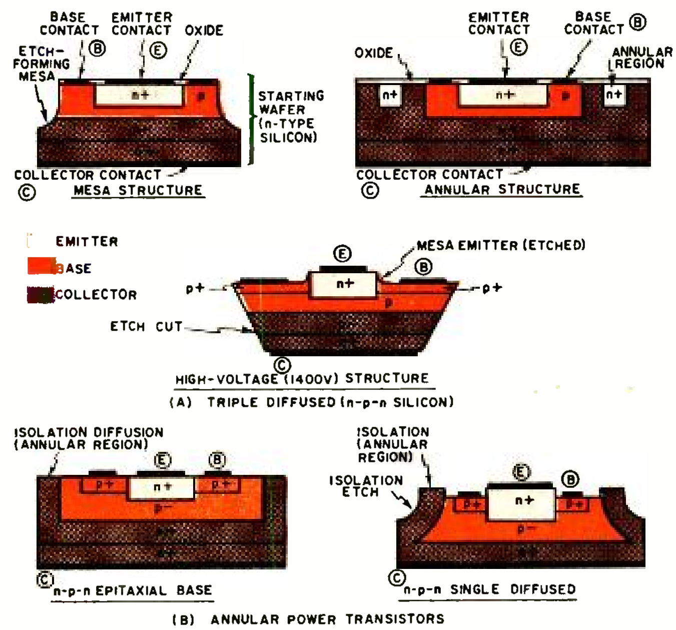


Fig. 2. Cross-sections of (A) three types of triple-diffused devices in which separate diffusions form "n+" collector, base, and emitter regions and (B) two types of annular power transistors.

manufacturing yields that result in relatively high prices.

That's where the diffusion process comes in. Diffusion techniques long ago superseded alloying in the production of small-signal transistors. The same thing has happened in silicon power transistors but, because of the divergent electrical requirements associated with the handling of large amounts of power, there are substantial variations in diffused transistor processing. In *single-diffused transistors*, for example, the impurities used to form the collector and emitter regions are diffused in simultaneously from opposite sides of the silicon wafer. Such devices feature excellent safe area, moderate breakdown voltage, low saturation voltage, frequency response to 1 MHz, and low cost.

To make a *triple-diffused transistor*, separate diffusions into the silicon wafer are used to form each of the active areas. These devices have substantially higher operating frequency and higher voltage rating than the single-diffused types, but have smaller safe-operating areas and higher saturation voltages. As a generalization they are also more expensive.

A third process using diffusion techniques is the *epitaxial-base transistor*, a popular, low-cost, general-purpose device available in both *p-n-p* and *n-p-n* types. It has good safe area, voltage ratings to 120 volts, frequency response to 10 MHz, and low saturation voltage. Complementary epitaxial-base power transistors with ratings chosen to provide maximum yields are becoming available at the low prices associated with germanium devices.

The oldest all-diffused transistor, the *mesa*, is named for the characteristic table mountains of the southwest. Its top is flat and the sides are etched to define and terminate the active regions. Mesa transistors are low in cost and rugged.

An alternative to the mesa structure is the silicon-oxide-passivated structure that has come to dominate small-signal transistor construction. Passivated power transistors have recently taken a step forward with the introduction of *annular power transistors*. The new annular power transistors demonstrate exceptionally low leakage—roughly 1/1000th that of equivalent mesa structures—and excellent results in life and environmental tests. Annular power transistors are ideal for defense and aerospace equipment and any other application where highest reliability is demanded.

Annular chips or unpackaged transistors will also likely prove popular in the growing field of hybrid circuits since their passivated surfaces make them easier to handle safely than earlier devices. Another important benefit of this construction is the excellent isolation it affords between adjacent structures on a single die, making monolithic power IC devices practical. Already available on the market is a compound-connected transistor (Darlington amplifier). Designed for critical high-reliability use, it has a current gain of over 10,000 at 6 amperes.

Characteristics of the different varieties are shown in Table 2, while Figs. 1 and 2 show the cross sections of the various types.

Critical Parameters

The trade-offs between parameters in power transistors have already been discussed. However, this leaves the question of which parameters are important in particular applications.

Power transistors in all applications must be evaluated for adequate safe operating area and junction temperature to insure reliable operation. In addition, the critical parameters for transistors used in linear applications, such as amplifiers and most voltage regulators, are minimum current gain at maximum collector current and maximum gain-bandwidth product frequency (f_T). The critical parameters for transistor switches are saturation voltages ($V_{CE(sat)}$ and $V_{BE(sat)}$), switching time, and minimum h_{FE}.

Reliable operation of power transistors is dependent on careful attention to the two limitations on the power-handling capability, the thermal rating and the safe operating area (SOA). Either rating can limit the amount of power a transistor can handle safely, and both must be considered in circuit design.

Safe Operating Area

The safe operating area curve of a transistor defines the limits of current and voltage to which the transistor can be subjected simultaneously without risking device failure. Simply staying within maximum collector current and voltage ratings is not adequate for reliable operation; the collector load line of a transistor must be kept within its safe operating region. Referring to Fig. 3, the transistor shown has a maximum continuous collector current rating of 4 A and maximum breakdown voltage rating of 40 V, but not safe to operate it above about 0.1 A continuous current at 40 V.

Safe operating area is dependent on pulse width as voltage and current since temperature is a function energy rather than power. As expected, transistors operated under switching conditions with fast switching times can

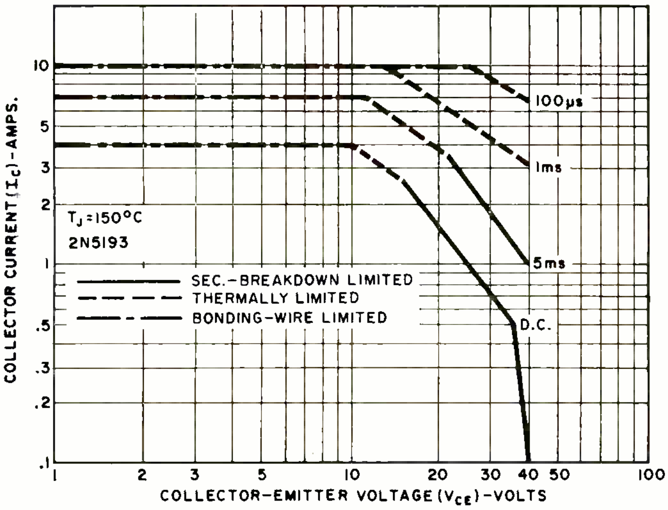


Fig. 3. Safe operating area curves of popular silicon power transistor. Collector load line must fall within safe area.

handle higher currents than they can in d.c. operation. The SOA graph includes information on pulsed as well as d.c. operation.

If safe operating area is not considered, and the limits specified are exceeded, secondary breakdown will likely destroy the transistor. Here is what happens: For a fixed bias on the base-emitter junction of a transistor, the collector current increases as the voltage between the collector and emitter rises. The increase in current is slow up to a certain point, where avalanche occurs and the current increases rapidly. The collector voltage at which avalanche occurs is dependent on the bias voltage across the base-emitter junction. Avalanche is not necessarily destructive; if current and hence power dissipation is limited, no damage will occur. (In fact, this phenomenon is used in zener diodes.) However, if current is allowed to reach an excessive value for long enough (perhaps only nanoseconds), the heating of the junction can result in the collector-emitter voltage suddenly dropping to near the saturation voltage of the transistor. This is the condition called secondary breakdown and is usually destructive. Secondary breakdown occurs at the collector-base junction, and is controlled by the base-emitter junction.

The exact mechanism of secondary breakdown is not known, although several theories have been advanced. The most plausible theory is that as the collector current increases there is a concentration of carriers in a small area of the junction. This concentration of current causes an increase in temperature, resulting in a "hot spot." If the temperature becomes high enough, the material at the hot spot will become *intrinsic* and will be unable to support voltage. (In an intrinsic semiconductor, the number of carriers produced by the heat is greater than the number produced by the doping.) This collapse in voltage usually results in an increase in collector current because of the circuit load and leads to a further increase in the hot-spot temperature. If this condition persists long enough, the semiconductor material will melt, causing a collector-to-emitter short. Even if a short does not occur, performance will probably be degraded.

Junction Temperature

The other major factor influencing transistor reliability ...ion temperature. Excessive junction temperature can ...nges in the distribution of dopants or even melt ...ductor material. Either will cause degradation ...l failure. Junction temperature is dependent on ...wer dissipation, transistor case temperature, the ...ance between the junction and the case and ...peration, the pulse width and the duty cycle.

The case temperature is dependent on the type of heat sinking used, the case-to-heat-sink thermal resistance, and the power dissipation. In most applications, the heat sink is air-cooled either by natural convection or forced air (although water-cooled heat sinks are used in high-power applications). Power dissipation must be limited at higher ambient temperatures since junction temperature "floats" on ambient. Pulse or switching operation of a power transistor naturally results in a lower junction temperature than d.c. operation.

Power-Transistor Packaging

Because the maximum junction temperature of a power transistor is critical, heat must be transferred away from the junction efficiently. The packaging of the die is, therefore, very important.

Power transistors are generally furnished in packages that can be attached to heat sinks for efficient heat transfer and consequent high dissipation. All germanium power transistors are packaged in air-tight sealed (hermetic) metal cases. Many silicon transistors are made with hermetic cases, but since the surface of silicon devices can be passivated to prevent contamination, molded plastic packages are also popular.

The oldest widely used power transistor package is the familiar diamond-shaped TO-3. It is still used for most germanium and many silicon transistors, though many changes have simplified it, reducing production costs and improving reliability. For example, early TO-3's were constructed entirely of copper. Now aluminum is used to make most TO-3 cases. Aluminum is lighter, cheaper, and not subject to the periodic upheavals in the copper industry that plague users. In addition, the welded seal in an aluminum case is even stronger and more reliable than that of copper cases.

For highest current levels, other cases are often used. Various stud packages are used for high-current silicon power transistors. These packages are available in sizes from 7/16" across the flats to 1¼". Because both the package and the assembly operations are costly, transistors in stud packages are normally expensive and most suitable for military and other high-reliability applications. The TO-36 "doorknob" package is used for many higher-current germanium transistors.

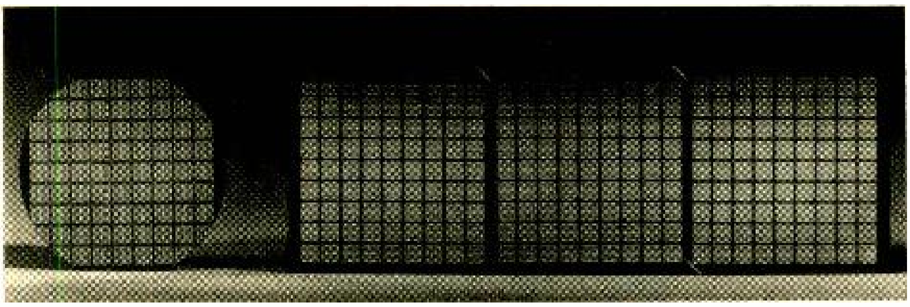
The space-saving TO-66 "small diamond" is becoming very popular for silicon transistors used in applications that do not require the power-handling capacity of TO-3 packages.

A rapidly growing number of silicon power transistors are packaged in plastic for minimum cost. The materials are usually less expensive than hermetic cases; even more significant, production can be mechanized to a high degree by manufacturing the transistors in long strips. This changes the assembling and testing operations from individual to batch processing and greatly reduces the labor cost per transistor.

Among the most popular plastic power transistor cases are two Thermopad packages: the larger, though only ½ x ⅝ x ⅛ inch, is capable of dissipating up to 90 W at a case temperature of 25° C. (The rating of a specific transistor is dependent on the silicon die used.) The smaller package is comparable to a TO-66 case in performance, and can dissipate up to 40 W. It measures 0.3 x 0.4 x 0.1 inch.

The high power capability of these small packages is a result of their short thermal paths. The transistor chip is bonded to a copper contact whose opposite face can be clamped to an external heat sink. The short heat path results in a very low thermal resistance.

The new Uniwatt case is designed to replace the TO-5 and TO-39 packages used in many low-power applications. Although it is not a high-power package, it is capable of dissipating over 5 watts at a case temperature of 25° C. This package is similar to a small-signal transistor package



Two-inch diameter wafers (at left) were formerly the largest used in manufacture of silicon power transistors. More recently, the 2 x 6 inch wafer at right has been used in order to improve production efficiency and reduce handling.

but the silicon chip is mounted on a copper tab that extends out of the case. The tab can be attached to a heat sink.

At present no plastic package is suitable for very high power, but some are being developed and will likely appear soon.

Recently developed plastic-encapsulated transistors have proven very reliable in both test laboratories and in the field, but they are not intended to replace metal units in all applications. They are most suitable for mass applications, such as consumer products. Plastic transistors have lower maximum junction temperatures than equivalent metal devices, and are not hermetic, hence not intended for extremely wet environments. However, they are more resistant to shock than conventional transistors because their bonding wires are supported by the plastic.

Germanium or Silicon?

An obvious question to the designer is whether to use silicon or germanium power transistors in his equipment. In some cases, the answer is immediate, but often each type has strong points and a compromise is necessary.

The most important consideration is often junction temperature. Many silicon transistors are suitable for junction temperatures of 200° C; germanium, of only 100° C. This, of course, determines power dissipation. Along with this, silicon devices feature much lower leakages, often less than 1/1000th that of germanium transistors. This greatly simplifies design, especially for high-temperature operation.

For high supply voltage (above 50 V), silicon is usually the choice, although diffused germanium devices can be used up to 300 V. At low voltages (below 12 V) germanium is often more suitable because the saturation voltage ($V_{CE(sat)}$) of common germanium transistors is usually lower than that of silicon. The higher saturation voltage of silicon can limit voltage swing at low supply voltages.

The low $V_{CE(sat)}$ of germanium can also mean lower loss and lower power dissipation at medium or slower speed switching applications. If the saturation voltage of a germanium transistor is 1/10th that of a silicon unit at a given current, the dissipation and heating can also be 1/10th as much. However, since silicon transistors generally switch much faster, the power dissipated during the switching times is less for silicon, and silicon is more efficient at high speeds.

For high currents, inexpensive germanium devices will handle 60 A easily, while silicon transistors rated at currents above 25 A have been relatively expensive.

At present, the greatest strengths of germanium transistors are cost and availability. Germanium prices are significantly lower than those of equivalent silicon transistors, although this is changing rapidly.

Silicon devices are much faster switches, switching in nanoseconds instead of microseconds, and they feature f_T's up to 100 MHz instead of the 1MHz and below that is typical of germanium.

An important advantage of silicon-transistor technology is the availability of complementary transistors with maximum collector currents up to 50 A. Modern amplifier design makes wide use of these versatile *n-p-n/p-n-p* pairs that can simplify power amplifiers while improving frequency response and reducing distortion. Power *n-p-n* germanium transistors never became widely available; hence complementary germanium pairs are limited in power and application.

In summary, germanium has the edge in low-voltage, high-current and low-cost applications, while silicon excels at high voltages, high-power dissipations, high frequencies, and where complements are desirable.

Applications of Power Transistors

Audio Amplifiers. An important application of power transistors is in stereophonic audio power amplifiers. Transistors are ideal for driving low-impedance speaker loads without expensive output transformers. Epitaxial-base complementary silicon transistors are used in many premium high-fidelity systems because of the wide frequency response and low distortion that they provide with simple circuitry. Before these transistors were developed, amplifiers usually used two *p-n-p* germanium output transistors in a totem-pole configuration.

Present power transistors are capable of up to 200-W output with a single complementary pair. For less demanding applications, a complete selection of complements is available for output power down to ½ W or less, making them suitable for even inexpensive children's phonographs.

Inexpensive plastic silicon transistors are helping complementary pairs make inroads in less-expensive sets, but at present, many high-power amplifiers use two germanium or silicon transistors driven by a small transformer (this transformer is less critical and less expensive than an output transformer).

The most popular audio amplifier in automobile receivers —a large market—is a simple single-ended class-A transistor amplifier that puts out 2 watts or so. Both germanium and silicon devices are used here.

Line-operated equipment with modest audio power requirements, such as TV receivers, table radios, clock radios, and inexpensive phonographs, can use a small silicon transistor in a circuit similar to that of the old a.c.-d.c. radios. A voltage rating of 300 V (twice the peak of the 117-volt a.c. line) is needed. This is a fairly stiff requirement since the price must be low, but an inexpensive plastic-encapsulated transistor fits the requirements well.

Power-Supply Regulators. Silicon power transistors, with their large safe areas, low leakage, high current ratings, high voltage ratings, and high dissipation are ideal for voltage-regulation applications. The most common type of regulator uses a series-pass transistor whose effective resistance is varied to maintain a constant output. High gain at the operating current is important since the reference current level is multiplied by the gain.

Integrated-circuit regulators, with their limited power dissipations but otherwise high performance, are often combined with power transistors to provide high-performance, high-power regulation.

Inverters and Converters. Power transistors used as switches with a square-loop transformer make an efficient inverter for changing a low-voltage direct current to a higher-voltage alternating current.

The output can be used to operate motors, synchros, fluorescent lamps, and other devices requiring alternating current. The addition of a rectifier (*Continued on page* 63)

Nomograms for

By DONALD W. MOFFAT

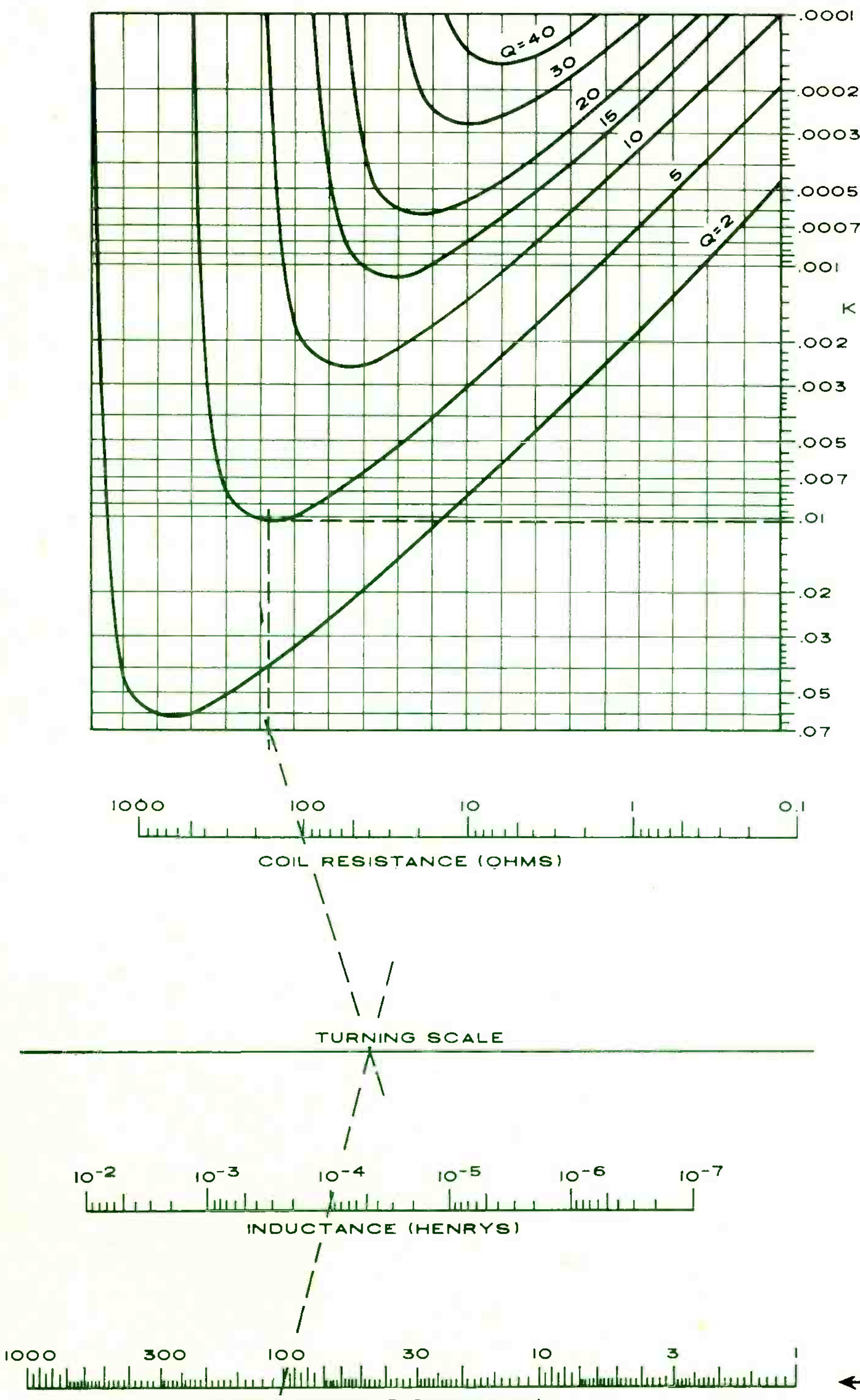


Fig. 2. Nomogram solves for resistance ratio when series resistance is known.

WHEN a circuit designer considers the tradeoffs between bandwidth and sharp response, and has selected the required "Q" for his resonant circuit, he then has the task of obtaining a "Q" which is neither higher nor lower than the acceptable range. The nomograms presented here will eliminate the need for time-consuming calculations in this final step.

In Fig. 1, R is the resistor that is in

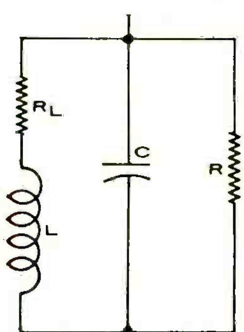


Fig. 1. Elements of a resonant circuit.

parallel with the resonant circuit and R_L is the resistance of the coil. These passive elements all have an effect on circuit "Q" according to:

$$Q = \frac{1}{\frac{1}{R}\sqrt{\frac{L}{C}} + R_L\sqrt{\frac{C}{L}}}$$

As would be expected, "Q" is increased when the swamping (parallel) resistance (R) is increased and/or the resistance of the coil (R_L) itself is decreased. In most design situations, one of these resistances is beyond the designer's control, as when R_L is the unavoidable coil resistance or when R is the input resistance of a following stage.

A ratio of the resistances can be defined as: $K = R_L / R$ and it is this ratio that the nomograms solve. With this ratio and the value of one resistance known, it is easy to determine a value for the unknown resistance.

Solutions may differ slightly from the theoretical equation, as empirical adjust-

Resonant-Circuit "Q"

These nomograms simplify resonant-circuit design by providing proper ratio of series to shunt resistance for the desired "Q."

ments, based on an analysis of measured data, have been made.

Using the Nomogram

Fig. 2 solves for the situation most likely to be present—when there is a choice of shunt resistance to use for obtaining the desired "Q," but the resistance which is effectively in series with the coil is fixed. To find resistance ratio K under these conditions, draw a straight line through appropriate values on the Capacitance and Inductance scales and note where that line crosses the Turning Scale. Draw a line from that crossing, through the appropriate value on the Coil Resistance scale, to the bottom axis of the curves. From that point on the axis proceed straight up, using the vertical lines as guides, to the desired "Q" curve. Finally, proceed straight out to the right-hand axis, using the horizontal lines as guides, and read the value of K which will give the desired results.

If the coil resistance, R_L, is the value which can be selected, Fig 3 is used for finding the resistance ratio, and the procedure is similar to that of Fig. 2.

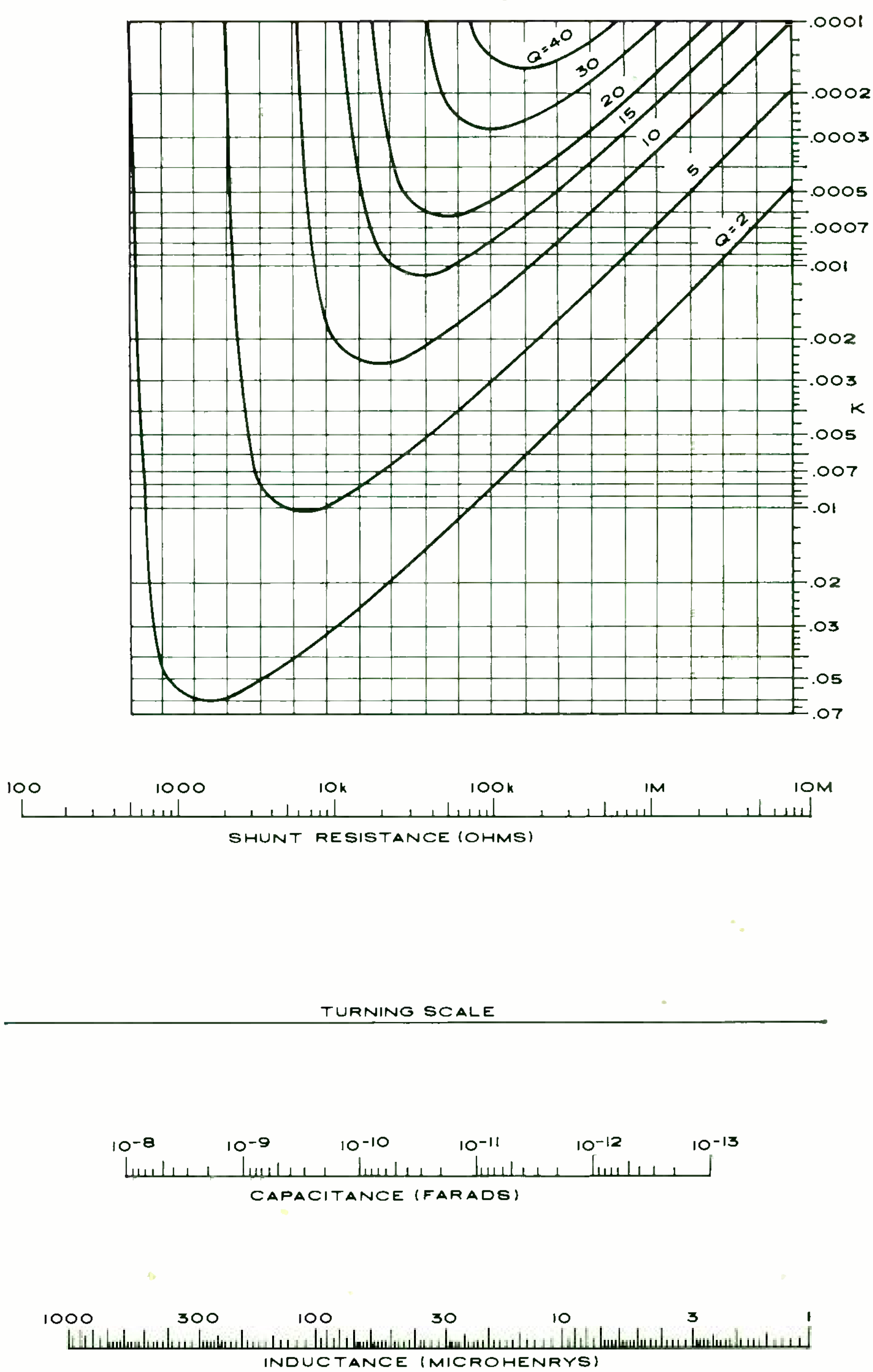
Example

A coil of 100 microhenrys inductance and 100 ohms resistance is to resonate with a capacitor of 100 picofarads, for a "Q" of 5. Since it is the value of the parallel resistor which must be found, Fig. 2 is used to find K.

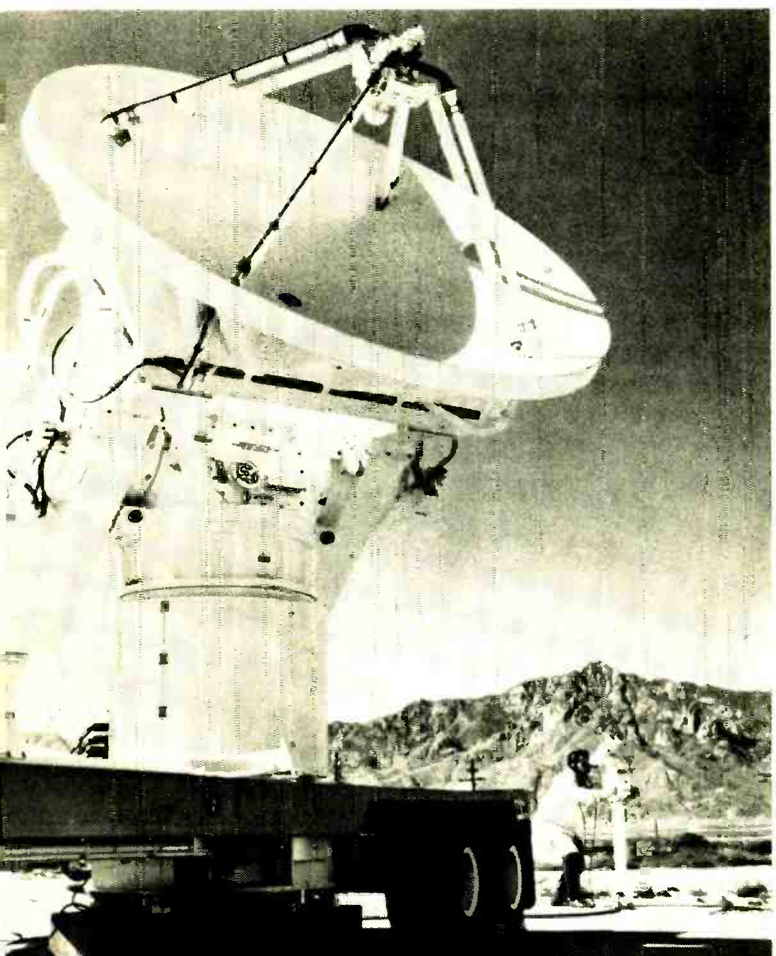
Locate 100 picofarads on the bottom scale, and 10^{-4} henrys (100 microhenrys) on the second scale. Draw a straight line through these points and note where it crosses the Turning Scale. From there draw a straight line through 100 on the Coil Resistance scale; that line will cross the lower axis of the curves just to the right of one of the vertical guide lines. Proceed straight up next to that guide line, to the $Q = 5$ curve, and then straight out to the right-hand vertical axis and read a value for K of just over 0.01.

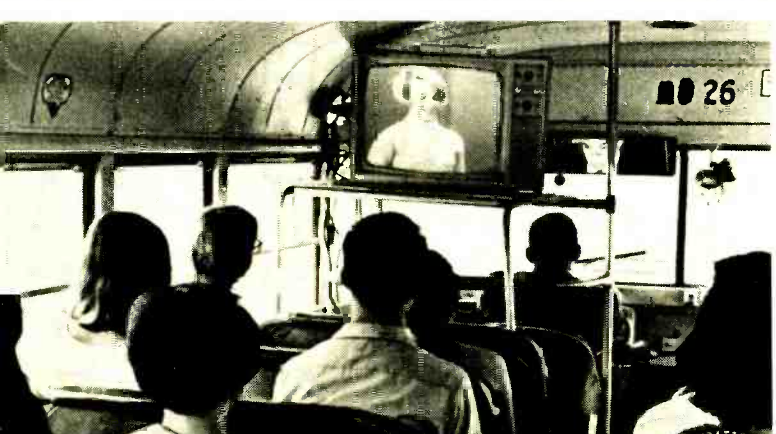
Since R is equal to R_L / K, these design objectives will be met if the resonant circuit has a parallel resistor of 10,000 ohms placed across it. ▲

Fig. 3. Nomogram solves for resistance ratio when shunt resistance is known.



Recent Developments in Electronics





Lie-Detector Research Aided by Computer. (Top left) Lie detector tests may be made more accurate because of computer-based research. Use of the computer allows more accurate analysis of critical factors in determining deception by a polygraph test subject. The project involves commission of a mock theft by student volunteers at Delta College, Michigan. Students then submit to the polygraph with instructions to answer all questions in the negative. The instrument graphs changes in heart rate, pulse amplitude, diastolic and systolic blood pressure, breathing patterns, and skin resistance. Many authorities consider the interpretation of lie-detector data, which is usually done by the operator of the device, unreliable and subject to human errors of judgment. By using a computer to correlate the data that is displayed on the polygraph chart, researchers hope to develop formulas that can be used to reduce errors in human evaluation.

Mobile Missile-Tracking Radar Turned over to Army. (Center) The first version of a new missile-tracking radar that can be moved from site to site and be in operation within eight hours after arrival was turned over to the Army recently. The antenna is mounted on a 36-ft trailer that can be hauled at speeds up to 60 mi/h. The new radar will be used to pinpoint trajectory and velocity of targets flown over the White Sands missile range, where nearly 2000 rockets and missiles are fired annually. It is the first instrumentation radar to have the capability for direct measurement of target velocity as an inherent part of the system design. The radar can track targets traveling up to 40,000 mi/h at ranges up to 32,000 nautical miles, measuring range to within 9 ft and velocity within 1 ft/s. During pre-acceptance testing, the radar maintained track on a 6-in balloon-borne sphere up to a distance of 87 miles (the design spec is 57 miles). The new system makes extensive use of microwave integrated circuits for reduced size and improved reliability. The missile radar was developed by RCA under a 4.9 million dollar military contract.

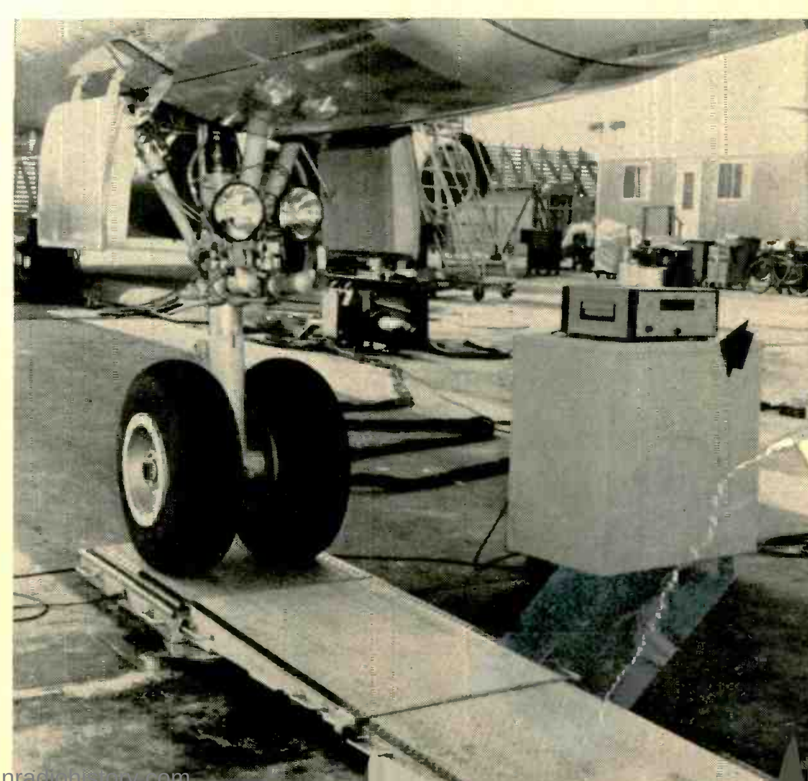
Educational TV in School Bus. (Below left) Students in Cayuga and Cortland counties (New York) are using two buses equipped with video tape recorders and TV monitors on trips to and from school and on field trips. The recorder, an Ampex VR-5100, is mounted on the floor of the bus behind the driver and four TV monitors are racked overhead. Some of the programs that have been taped for viewing by the students include: "Apollo 9—a Journey into Space," "Birth of a Volcano," "The Universe," and "On Clouds—Local Weather Indicators." The program is now being conducted on an experimental basis for about 6 months. If the experiment shows that it is an effective educational device, then it may be implemented on a statewide basis. Equipment will then be installed as standard on school buses that transport students for long distances.

Individual Teaching Unit uses Records, Slides. (Top right) Instruction for individual elementary-school students is possible with a new audio-visual system recently tested at three Chicago public schools. Special film slides, with 80 color frames, are used which have coded holes on either side. The holes key the location of the phono stylus onto a special record when the student depresses one of the buttons in response to a question or statement on the slide. The record "talks" to the student just as a teacher would. The units are sold by Borg-Warner at about $500 each and each 10-lesson kit costs $125.

Computer Terminal in Attaché Case. (Center) "Talking" to a computer from any standard telephone—even one in a roadside booth—will be a simple matter with a portable terminal built into an attaché case. A salesman on the road, for example, could take the new portable audio terminal into a phone booth and enter orders directly into a home-office computer. He could also use the terminal to check product inventories. The computer draws on recorded words stored in its audio-response unit and these are transmitted over the phone lines to the portable terminal's speaker and earphone. The new portable terminal weighs 10 pounds and rents for $20 a month from IBM.

World's Largest SCR Light Dimmer. (Below left) The operator is sitting at the control desk of what is claimed to be the largest SCR light-dimming system (486 dimmers). The system was developed by Toshiba for installation in a new 5000-seat auditorium in Tokyo owned by a Japanese Buddhist organization. Despite its complexity, one man can operate the system. It has a computer-controlled memory that enables as many as 150 programmed color-lighting effects to be preset, memorized and executed automatically. The system includes 251 six-kilowatt, 120 three-kilowatt, 92 ten-kilowatt, 17 twelve-kilowatt, and 6 one and a half kilowatt individual SCR light dimmers.

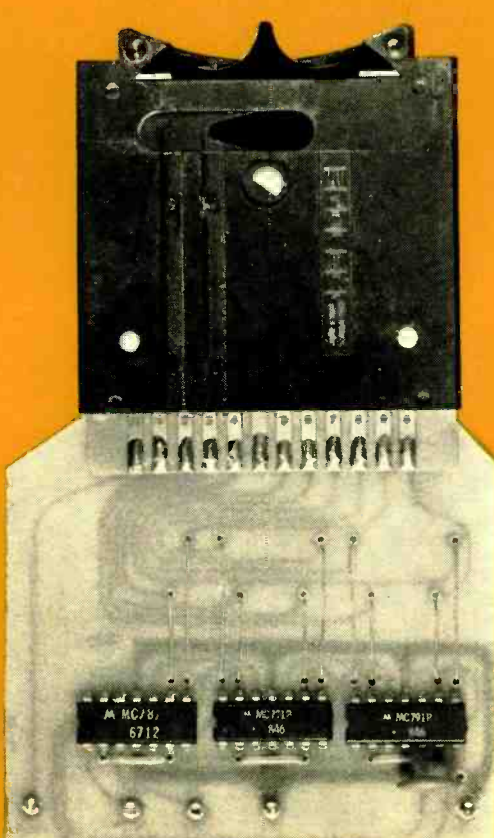
Electronic Scale for Giant Jet. (Below right) A portable aircraft platform weighing system for the Boeing 747 is shown here being tested under the nose wheel of a 4-engine jet aircraft. Each of the weighing platforms has a 200,000-lb capacity, enabling the system to handle a fully loaded 747 with its maximum take-off weight of 710,000 lbs. Electronic load cells in the platform sense the applied load and send a voltage which is amplified and measured by the equipment shown at the arrow, giving instantaneous digital indication of weight. Equipment is made by Revere Electronic Div., Neptune Meter Co.



Predetermining Decimal Counter

By DONALD E. LANCASTER

A unique, inexpensive decade counter that can be cascaded to divide by any number from 1-99, 1-999, etc. It uses an ordinary single-pole, 10-position selector switch in place of usual gates and/or decoding circuits.



Prototype version of RTL predetermining decimal counter mounted on the back of thumbwheel switch.

TODAY'S digital circuit designer has a wide choice of decimal counting techniques available. Many of these general-purpose techniques have been described in past issues of ELECTRONICS WORLD ("IC Decimal Counting Techniques," September, 1968, "IC Frequency Dividers & Counters," December, 1968 and January, 1969) and are also covered in the author's book, "RTL Cookbook," published by *Howard W. Sams & Co., Inc.* Described here is a special-purpose decimal counter with several unique features.

This counter is simple and low in cost. It takes three IC's and one single-pole, 10-position selector switch, and can be built for as little as $8.50 per decade. The technique works with any IC family; RTL (Resistor-Transistor Logic) is used in the prototype circuits and kits of both TTL (Transistor-Transistor Logic) and RTL are available.

What makes the counter unique is that you can force it to count to any selected number from 0 to 9 and then repeat or stop. This is done using no gates, no decoding, and only an ordinary single-pole, 10-position selector switch (either rotary, thumbwheel, or push-button). Even more unusual is the fact that you can directly cascade counter stages without any additional circuitry to form 0-99, 0-999, 0-9999, etc. predetermining counters that can be directly preset to the desired decimal number. Note that if we attempted to cascade an ordinary divide-by-three with a divide-by-two and a divide-by-one, we would get only a divide-by-six output. This circuit will divide by 321 when three such stages are preset and cascaded.

The circuit is called a *phase-shift ring* and is a simple and new variation on a popular decimal counter called a walking-ring counter, also known as a Johnson counter, switchtail ring, etc.

On the debit side, to get the required cascade arrangement, this counter counts in a very odd-ball manner; it cannot drive a readout or provide an electrical output on anything but the selected count. It's also necessary to throw in a "free" count at the beginning of each use—but we'll shortly see that this is very easy to do.

Applications

A counter of this type can be used anywhere you want a set of knobs or a series of thumbwheels that you can set to some decimal number and, in turn, get out either that many events or pulses, a signal that lasts for that many counts, or a ratio between either pulses or frequencies of the preset number. Some typical applications are in predetermining process controls that stop on a preselected count; digital photo timers that count the power line for excellent long-term accuracy; lab scalers for dividing down input frequencies of nuclear pulses and other instrumentation signals; frequency synthesizers, either as v.f.o. replacements, musical-tuning aids, or ultra-stable audio oscillators; and computers and calculators either for keyboard entry or pulse-rate computation circuits.

How It Works

The well-known walking-ring decade counter is shown in Fig. 1. This popular circuit uses five JK flip-flops (boxes) to perform decimal counting.

Each flip-flop is a storage device and has a Q and a $\overline{Q}$ output. These outputs are always *complementary* in that if one is grounded the other is always positive and *vice versa*. In this circuit, whenever the input to the flip-flop's "T" terminal abruptly goes from "+" to ground, whatever *was* on the "S" (Set) and "C" (Clear) terminals gets passed to its corresponding Q and $\overline{Q}$ terminals. A built-in time delay (90 nanoseconds for RTL) assures that the stored information is passed along *only* one stage at a time. Thus, each flip-flop, under command, passes the signals on its outputs one stage to the right.

To make a counter, we add a *buffer* (B triangle) between the count input and the Toggle terminals (Fig. 1). This gives us enough power to drive five Toggle inputs synchronously without requiring an excessively strong input signal. The buffer also inverts the input signal, so that any time the Count input goes positive, a negative transition from "+" to ground is sent to each Toggle input, and each flip-flop passes its input to the flip-flop on its right.

We also have an inverter and a buffer on the Reset (C_D) input and whenever the Reset input goes positive, all of the flip-flops immediately go into the state with the Q outputs grounded and the Q outputs positive.

Suppose we reset our counter and call a positive terminal condition a "0" and a grounded condition a "1." Looking at the Q outputs, our counter will be in a state of 11111. With the receipt of one Count input pulse each "1" (Q output) will pass to the flip-flop on the right. However, the rightmost "1" is effectively complemented (becomes a "0") when passed to the leftmost flip-flop, giving us 01111. This occurs because the "0" (Q) output of the rightmost flip-flop is present on the S input of the leftmost flip-flop when the count input pulse arrives. As shown in the timing diagram of Fig. 1, additional Count pulses sequentially advance the counter to 00111, 00011, 00001, 00000, 10000, 11000, 11100, 11110, 11111, and then begins to repeat itself. There are ten different states, so this is a counter that repeats itself every ten counts.

If we were building an ordinary decimal counter, we probably would decode each state with a two-input gate, and proceed to drive a readout of some sort. We would probably also add a protection circuit to guarantee that the counter does not deviate from the above sequence.

The Significant Difference

The key to the predetermining phase-shift counter lies in how we use the basic walking-ring circuit. Look at the waveforms of Fig. 1; each output has one, and only one, positive transition *per* 10 counts, and there is a *different* positive transition available at some terminal for each of the ten counts. We simply use a single-pole, ten-position selector switch (Fig. 2) to route the *selected* positive output transition to act as the Carry input for the next stage. Thus, instead of carrying on a zero after count nine, we select a carry that corresponds to the selected positive transition.

Suppose we cascade several decades and reset them to zero. The first time each decade goes around, it counts by the *selected* number; on all succeeding counts, it divides by ten. Whenever we reach the desired total count, a positive Carry output is produced, which can stop the process, turn off the timer, or can be used to recycle the counter for continuous operation.

Problem Zeros

The above scheme works fine on most counts, but zeros can present a problem. If a counter decade is set to zero, a positive transition may not be obtained until the counter goes once around, throwing off the total by at least ten counts. Clearly, something has to be done to the basic counting idea to get the counter decade to work for all settings.

There are several possible solutions: One is to add an external gate to the first stage and re-define the first stage switch positions. While this works, it makes the first decade slightly different from the others, leading to two different kinds of PC layouts and possible later mixups.

Another reasonable alternative is called the "Add One" technique. This is the one used here. To get the counter to work properly for any count, we reset to 9999—instead of 0000. We also toss in a "free" count at the beginning to make up the difference. The free count is easy to pick up—we'll see just how in a minute. With the free count, even if we have a counter set to zero, we'll still get the needed carries at the right time, and the circuit will work for all counts.

The practical counter is shown in logic-diagram form in Fig. 2 and a schematic of the RTL prototype version is shown in Fig. 3. (A kit of all parts shown in Fig. 3, less switch S1, but including etched and drilled PC board can be obtained from *Southwest Technical Products*, Box 16297, San Antonio, Texas 78216 for $8.50 per decade, postpaid. TTL version is available at $10.50 per decade, postpaid.) The prototype unit is shown in the lead photograph. Prototype and kit units can be mounted on the back of an *Intermarket* thumbwheel switch, Type S110XD (*Allied Radio* #56 D 6964).

An Example

The counter counts in a very unorthodox manner, but gets

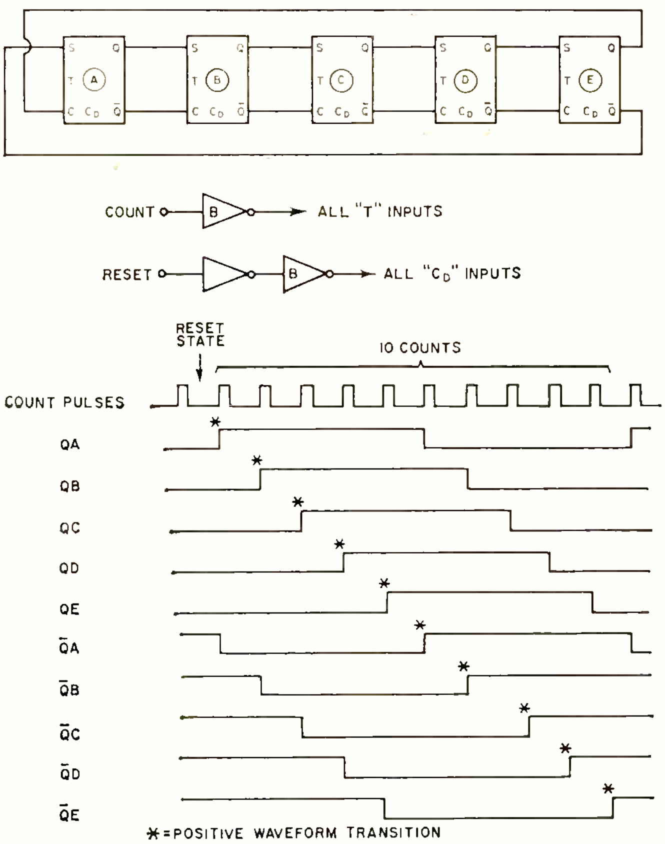
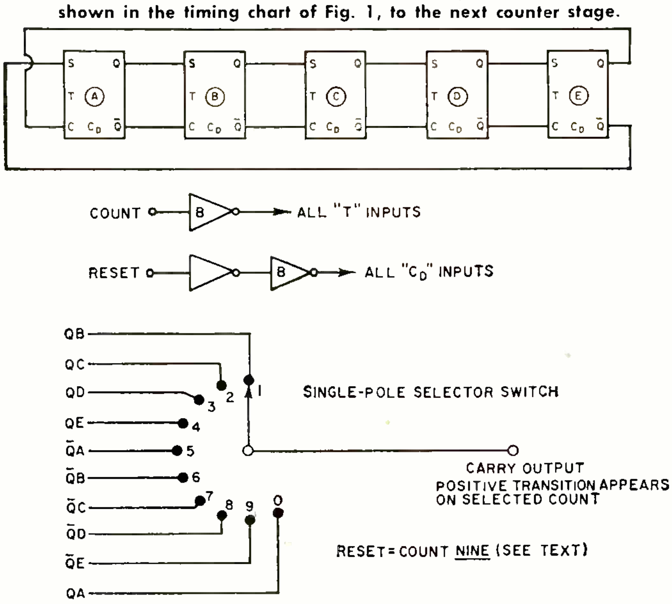


Fig. 1. Logic diagram and timing chart of walking-ring decade counter. Data present on "Q" outputs of each JK FF, except for rightmost FF, as noted, is passed on to FF on its right when the count input pulse is fed simultaneously to all "T" inputs.

Fig. 2. Walking-ring decade and single-pole, ten-position selector switch used to develop the predetermining counter. The switch is set to route one of the positive output transitions, as shown in the timing chart of Fig. 1, to the next counter stage.



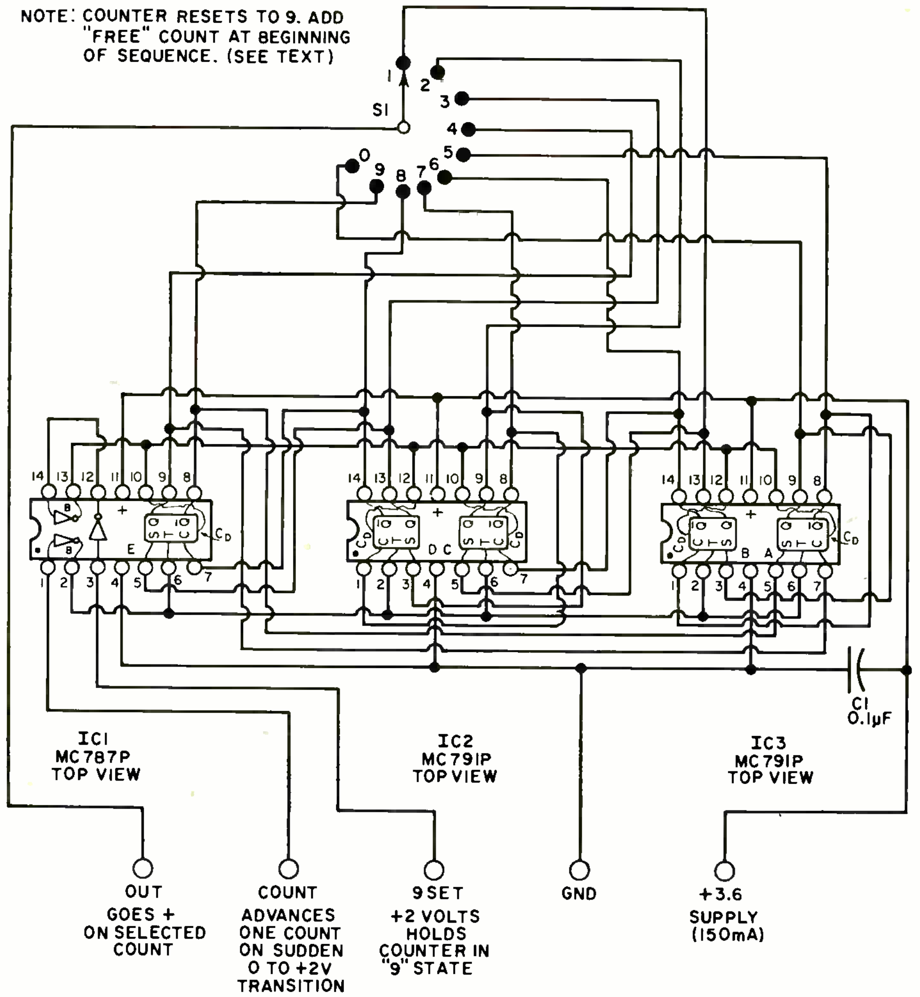


Fig. 3. Schematic diagram of the RTL prototype version of the predetermining decade counter using a rotary, 10-position selector switch.

the job done with a minimum number of parts and at minimum cost. Let's look at a typical count situation that will help explain the operation of the predetermining counter.

Suppose we cascade two stages that are set to give us an output after seventeen counts.

The fastest counter will produce a positive carry on count "7." The slower one will produce a carry and a useful output signal on count "1."

We reset our counters to 99 and throw in a free count. This gives us a 90. No carry is produced because the fast counter is set to carry on "7," not on "0." Now we start counting: 91, 92, 93, 94, 95, 96, 07. Here a carry was produced, because we carry on count "7" with the faster counter. We continue: 08, 09, 00, 01, 02, 03, 04, 05, 06, 17 and get a positive output transition on the last count. Going back to count all the numbers after the free count, you'll find it took just exactly the preset 17 counts to get an output. (Note the 00 condition pops up in the middle of the count instead of at the beginning, guaranteeing a positive pulse, if needed, at the right time.

Some Precautions

As with an electronic counter, we have to obey some rules to get it to work properly. With RTL, we have to have a well bypassed power supply with good grounds and be within 10% of 3.6 volts. About 150 mA is needed per decade, or around an amp or so for a complete six-decade chain. The operating frequency of the RTL version approaches 8 MHz, but the control and recycle circuitry slows things down considerably. Without careful design techniques on the control and reset circuitry, a 1-MHz limit is practical for the circuit; more can be obtained by careful consideration of the control and recycle timing pulses.

All input counts must be made bounceless and noise-free, going positive once and only once per desired count with a rise-time of 1 microsecond or faster. We can cascade decades directly by connecting the Carry output of the first to the Count input of the next one. We can only let the counter run once, and then reset it to 9999 . . . , throw in a free count, and start over again. It is also wise to *hold* the counter in the 999 . . . state between uses. This eliminates any chance of starting off on the wrong foot.

The output consists of a positive-going signal on the selected count, whose leading edge may drive up to two logic gates for outside control. Any "Add One" circuit added to the input must insure that the extra add-one command arrives either before or between normal count pulses; otherwise it could be missed.

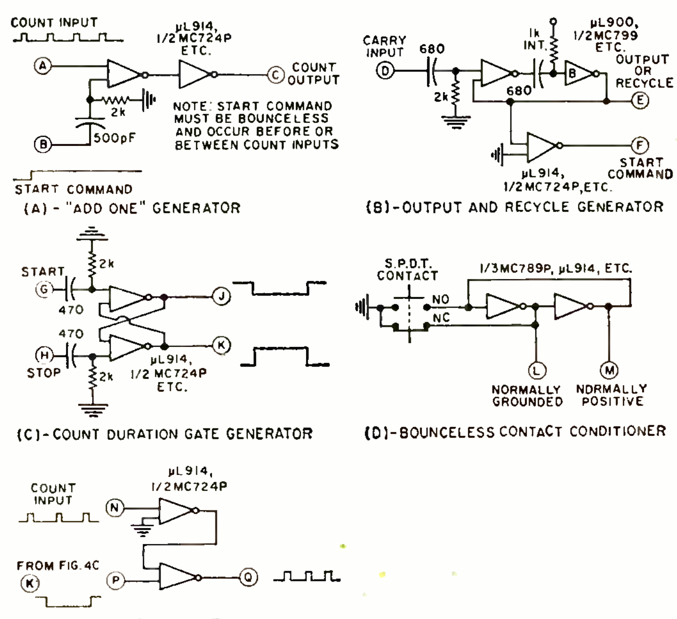
Control Circuitry

We do have to add some outside circuits to get the counter to work. Even with the most complicated version of these circuits, we still gain a lot in parts count and simplicity, where we swap one set of outside logic for simplicity in six or seven decades.

Let's turn to some control circuit blocks. Fig. 4 shows some RTL versions of these control blocks.

Fig. 4A is an "Add One" circuit. It combines the input count pulses with a single pulse taken from the leading edge of a Start Command rectangular waveform. The leading edge of the Start Command is differentiated and then *or*-ed with the normal input counts. For this circuit to work, we have to guarantee that the Start Command goes positive either before or between the count pulses, and that the Count input line is normally grounded between input counts. (*Continued on page 66*)

Fig. 4. Some RTL versions of control circuits required when using predetermining counter for applications shown in Fig. 5.



A Vocation Profile:

The Chief Engineer of a Small RADIO STATION

By KENNETH B. KNECHT / Supervisor, TV Eng.
State University College, New Paltz, N.Y.

Here's what the job involves along with a description of its requirements. Duties are varied, especially at a small station.

THE chief engineer of a small radio station is usually a busy man. He should have the last word on anything technical concerning the station. He may find himself announcing or reading the news. He has to maintain the equipment, and there is a lot of it; at some time or other he will find himself designing a new system, possibly a new control room or production studio, and selecting the equipment for it. He may even have to design the whole plant, as when putting a new station on the air. He may be the only engineer on the staff, if the station is an FM and/or a non-directional AM one. He will probably work six days a week, and will be on call whenever he isn't at work.

If the station is a larger one, or a directional-AM one, he will have one or more engineers on his staff. However, these other engineers could be combo men (combination announcers/engineers). Combo men are usually not technically oriented, even though they have a first phone (First Class Radiotelephone Operator's) license. They do satisfy the FCC requirement that a first phone licensee is in control of the transmitter or supervising its control by a lower class licensee if the station has a directional antenna. If the station is not directional, the FCC requires only that a first phone licensee be on the staff and inspect the transmitter once a day, five days a week.

The control room and offices will probably be in the business district of the area being served. The AM transmitter site will most likely be in a rural area, and the transmitter will probably be remote-controlled. If the transmitter is not remote-controlled, a man will have to be on duty at the transmitter as long as the station is on the air. The class of license he must

◀ Our author is shown here preparing to cue an announcer.

hold will depend on whether the antenna system is directional or not.

The chief engineer will have to have a first phone, a good theoretical electronics background, and a little experience in broadcasting. A background including a few years of experience with amateur radio and high-fidelity equipment would be a big help. There are several good books on the subject, including *Howard Sams'* "Broadcast Engineering Handbooks." The chief should have the last word on equipment purchases, and he will have to purchase spare parts and components for any construction work underway. He will probably have a certain amount of money set aside in the budget for purchasing whatever he might need. He will have to schedule his time and that of his staff, if any, for efficient and legal operation of the station. He should keep records of all work done on the equipment. This has a twofold advantage; it can help when the same trouble recurs at a later date and it is useful when trying to anticipate future maintenance time and costs. It is also a help in trying to plan a preventive-maintenance schedule.

Designing the Control Room

The control room usually contains the mixing console, turntables, cartridge tape machines, reel-to-reel tape machines, probably a transmitter remote-control unit, and, oh yes, an announcer. There will also be one or more racks containing some of the above equipment, patch panels, a.g.c. amplifier, and the other assorted amplifiers and power supplies required. The control room should be large enough to contain a table for interviews or the news man and all his copy.

When designing a control room, there are a lot of things to keep in mind. It is wise to keep all levels in the system the same. We like to keep all our high levels at 0 dBm. This may require some padding of outputs. For example, some mixing consoles actually put out +8 dBm, even though the vu meter reads 0 dBm. However, the amplifier feeding the telephone line to the transmitter (if at a remote location) should be +8 dBm. The phone company usually doesn't want you to feed a higher level because of possible cross-talk. Of course, the microphones will operate at a much lower level than the rest of the system, usually around −55 dBm. The cables carrying this signal must be well separated from the cables carrying 0 dBm. Keeping all the levels alike makes trouble-shooting simpler and cross-talk less likely. We also find it useful to keep all audio (except mikes) balanced and terminated in 600 ohms and all inputs high-impedance balanced bridging. The only exception to this would be the telephone lines to the transmitter, and remote broadcast and network lines. These inputs should be 600 ohms balanced.

When wiring the system, use two-conductor shielded cable, and keep the different signal levels well separated. When possible, power cables should be run in grounded conduit well away from the audio cables. Audio cables should also be run in grounded conduit. Everything possible should be routed through the patch panels. This can save a lot of time when troubleshooting. It also makes temporary substitution of equipment very easy. When installing a new system it is usually best to connect all the cable shields at the console and let them float at the other end. Then you can experiment by grounding the floating shields and checking to see if that changes the signal-to-noise ratio. Make final connections looking for the best ratio. Wiring should be routed through terminal blocks when going to or from the patch panel. This makes testing, re-routing, and wiring simpler.

You will need several monitoring systems. Some or all of these might be included in the mixing console you choose. You will want to monitor your signal off the air, that leaving the console, and the second channel or audition side of the console. This is usually built into the console and a switch is available for making the selection. The off-the-air signal is provided by an external tuner. Another monitor system permits the announcer to listen to his turntables and tapes without putting them on the air. This allows him to cue them up at the point he wants. This could be done using the audition portion of the console but a cueing monitor is much more convenient. Usually there is another amplifier to feed the programming around the building. This can be the output of the console but is usually an off-the-air pick up. Relays and/or switches are required to cut the speakers when a mike is turned on in that room. Unless the news is read from the console, a switch, called a "cough-switch," should be provided at the news position so that the news man can turn off his mike if he so chooses. The switch should short out the mike, not open the circuit. Lights that go on when the mike is opened should be provided over the doors or in rooms containing mikes.

Switches should be provided to start and stop the tape cartridge machines, unless they are located very close to the announcer. He should not have to move his head to start the tape cartridge machines or the turntables. The turntables are usually located right next to the announcer and are not remote-controlled. It should be possible to record with or play the reel-to-reel tape machine *via* remote control. Fast-forward and rewind control are usually not necessary.

Equipment should be located with the announcer in mind. He should be able to load cartridge machines and cue records

Using v.o.m. to measure the voltage in a tape transport.

without leaving his chair. A rack for tape cartridges and a place to store records for his show should be right at hand. If possible, the reel-to-reel tape machine should be reasonably close by too. There should be a place for the announcer to put copy and a clock, both visible while speaking into the mike. Preferably, the copy board should be directly over the console, with the mike on a boom over that. The announcer also needs a convenient writing surface to use for keeping the program log.

Grounding is very important. All the equipment should be connected together with one really good conductor, such as 2" ground strap or #0 copper wire. This ground should be connected to a good earth ground if at all possible.

Choosing the Equipment

The equipment should be the best you can afford. It is best to buy new equipment and preference should be given to solid-state gear. It usually is smaller and more reliable than its vacuum-tube counterpart. Try to get equipment using plug-in modules. Numerous front-panel test points are also useful. A good point to look for is ease of disassembly for maintenance. Of course, electronic specifications are important too; however, most name-brand audio units have good specifications. One thing to look for is *head room,* that means an amplifier rated for 0 dBm nominal output level should be capable of at least 18-dBm levels for short periods without clipping or noticeably distorting the signal.

In a turntable, look for a simple unit, with few if any mechanical adjustments, rim drive, low wow and flutter, and enough torque to bring it up to speed from a dead stop in half a turn or less at 45 r/min. It should be possible to hold a record on the table to keep it from turning without noticeably slowing down the platter. Turntable preamps should have 0-dBm output.

Cartridge tape machines should be chosen for quiet, sure operation with good frequency response and steady speed. Ease of maintenance is important as these machines usually receive a lot of abuse and need frequent servicing. The head azimuth and vertical position should be screwdriver-adjustable. Plug-in modules are nice to have, too. Quiet operation is important so the microphone doesn't pick up the machine starting noise if it is open at the time.

The reel-to-reel tape machine should operate at 7½ and 15 in/s. It can be full- or half-track, full-track preferred. A machine with three heads and a separate record and playback preamplifier should be chosen. It should accept a low-impedance microphone and also have a bridging (at least 20k-ohm) input. The machine should be solenoid-operated for easy remote control. It is a good idea to look at the machine to see how hard it is to change motors and solenoids, if that should be required later. The brakes should be easily adjusted. Bias level and record and playback equalization should be externally adjustable.

When selecting a mixing console, get as many inputs as possible. It is virtually impossible to have too many. It is nice to have inputs that can be used for either microphone or line-level inputs by switching or changing plug-in modules.

Look for high-grade attenuators that can be cleaned. Two output channels should be sufficient. It is nice to have a separate vu meter for each output channel. All attenuators should have a switched position at their point of maximum attenuation which feeds that input into the cue amplifier. The cue amplifier should be mute when the mike is turned on. You can get a standard console, a custom-built console (expensive), or buy all the parts and build your own. The console should be followed by an a.g.c. amplifier before the telephone line to protect it from overloads. This will also keep your modulation percentage up, but you should be careful not to overdo it or it will not sound natural.

Good-quality cardioid mikes for the announcer and news man, a couple of omnidirectional hand mikes, which can also be used as lavaliers or table mikes, should get you started.

Routine maintenance of station equipment is required. Here the author is tightening motor mount in the studio turntable.

Of course, if you plan on studio productions, more and better mikes will be required, along with booms and stands. Ribbon mikes are nice but we've found that for AM a good dynamic mike usually sounds about as good and is a lot less fragile. For a high-quality FM studio buy the best you can afford.

The Transmitter Site

The transmitter will probably be at another location. It will likely be in a small building with one or more AM antennas and/or an FM antenna system. If AM-FM, the FM antenna will usually be mounted on one of the AM towers. The station management usually hires a consulting engineer to help them find an available frequency, get the construction permit from the FCC, and design the antenna system. All you should have to do is supervise the antenna installation and then hook it up to your transmitter.

In choosing the transmitter, you will be limited by the amount of power you are allowed to use. The only other things you will need at the transmitter are a limiter to protect against overmodulation, a frequency and modulation monitor, an off-the-air program monitor, and a remote-control unit, if used. If your system is on AM using more than one antenna, you will also need a phase monitor. If the station is FM only, the transmitter will often be next to the control room, visible through a window, and the antenna will be on a tower on the roof of the building.

When wiring, use all the same precautions you employed in wiring the studio. Always keep grounding and possible cross-talk in mind. Run all the audio through a patch panel. An extra telephone program line between the studio and the transmitter is handy in case of failure. If you don't have remote control, you can use it as a hot line between the two locations by hooking up an EE-8 surplus Army field phone at each end. If you have remote transmitter control it usually includes a method of talking back and forth.

The telephone company will take care of the lines and any terminal equipment required to equalize the lines. If you

Performing an adjustment on the studio's volume limiter.

have any problems with frequency response or noise, you will have to call them. They will measure the noise or frequency response to verify the complaint and then correct the problem. You should be sure, through your own tests, that the line is indeed at fault as some companies now charge you if you have them measure the lines and there is nothing wrong.

The limiter should be a reliable solid-state unit with adjustable release time. It should have a 600-ohm input to match the telephone equipment. Once set up, it should require no further adjustments unless a component fails. There are usually a few simple checks listed in the instruction manual that should be performed from time to time to assure proper operation.

Checking the Transmitter

The transmitter will probably require the most maintenance. You have to carry spare tubes for it, in a ratio of one tube for every three used. You are better off to carry a complete set of spares for your AM transmitter and a complete set of spares for the high-power stages of the FM transmitter. If it uses gas or vacuum-tube rectifiers, you should have a spare set that has already been cooked standing by. That way you can avoid the fifteen-minute wait before you apply the high voltage. This can be expensive off-the-air time.

The transmitter should be kept as clean as possible, especially the high-power stages. This can help avoid arcing. Variable coils should be kept clean, so that the tap will make good contact. All terminals should be checked regularly for tightness; this can avoid a lot of grief some day. If possible, the transmitting-type mica capacitors, if used, should be checked right after sign-off for higher than normal temperature. This is a sign the capacitor is ready to break down and this condition may put you off-the-air at some inopportune moment.

While you are in the transmitter, check the temperature of the power transformers. If unusually hot this can mean something is drawing excessive current or the transformer has a shorted turn. Be sure to short out all capacitors with a grounding stick before you put your hand into the transmitter. Also be sure to turn off the transmitter, as you will still have low-voltage d.c. and 120 V a.c. in the transmitter, even with the door open. The doors are interlocked to turn off the high voltage. These must *not* be jumpered.

It is also a good idea to occasionally check the peaking of the drivers and the dip of the final. You will usually find that the transmitter will be more efficient if you run the final about 50 mA out-of-resonance for every ampere of final current you draw. By watching the antenna-current meter you can see in which direction out-of-resonance you should operate. Choose the side that gives you the most antenna current. The modulator balance should also be checked frequently. Also check the high-power tubes for proper plate color while operating.

If you have a directional antenna system, you will have a field-strength meter to measure the FCC-required monitoring points to be sure they are in tolerance. This assures proper radiation pattern. The field-strength meter is also used to check the operation of the antenna system when first used. These readings are retained and can be used to assure proper signal strength in various areas if the question should arise at some later date.

The antenna-ground system is one of the most important things about which to concern yourself. The consulting engineer will probably specify the antenna-ground system and you should be very sure the installers do it correctly. All connections should be made with silver solder. Be sure you connect the grounding system just as carefully to your transmitter, and phasor, if used. The phasor splits the power and determines the phases of the various towers in a directional antenna system. It will be custom designed for your system by the consulting engineer and adjusted by him when you first set up the radiation pattern. If you don't know what you are doing, don't play with the adjustment, or you will be paying someone to come in and readjust the phasor, or get a pink ticket from the FCC, or probably both.

Proof of Performance

You should know about the two types of "proof of performance" required. The first is the r.f. proof, using the field-strength meter. This should be supervised by your consulting engineer, and with any luck, as long as you don't change any part of your antenna system, you will never have to run another. Be thankful because it is a long, dirty, meticulous job. The other proof is the audio proof of performance. This is required at least once a year at license-renewal time. It is useful to run a proof, or at least a spot proof, every three months. The proof consists of measuring system distortion at various frequencies, at various transmitter modulation levels. The frequency response is also measured, along with the residual noise in the system. Among other things, transmitter harmonic output is also checked. The FCC allows only a small latitude in these readings. If the readings are not within these specifications, the trouble will have to be found and repaired, and another proof run before measurements are required by the FCC.

The FCC requires you to keep, aside from the program log, a maintenance log and a log of all the required meter readings taken during that 24-hour period. The transmitter-site equipment has to be checked for proper operation every weekday. Depending on the terms of the license, there are other readings that will have to be made. These will vary from station to station. The maintenance log should include any maintenance done to the transmitter-site equipment, any off-the-air time with explanation, any license violations and their method of correction, tower light lamp changes, and anything else you want to keep tabs on, including the weather. Any operation with a defective piece of equipment required by your license has to be reported to the FCC. Emergency broadcast system equipment, as required by the FCC, will also have to be provided. This will include a monitor, a teletypewriter alarm circuit, and the required weekly test transmissions.

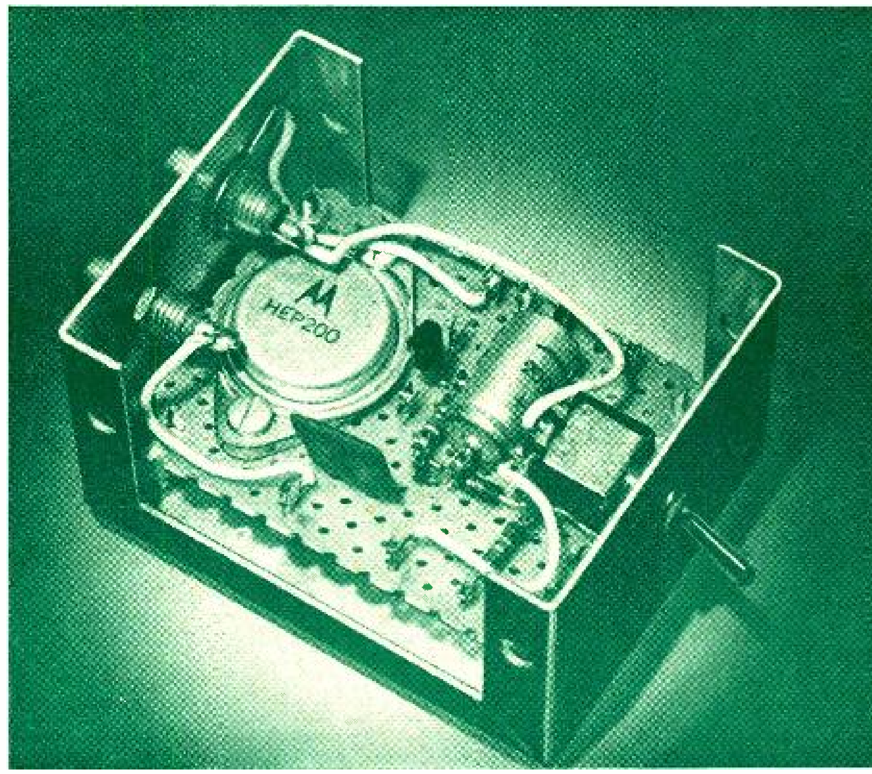
Minimum test equipment should include a good high-impedance v.o.m., an audio scope, a tube tester (or a good selection of spare tubes), a good audio oscillator with level set and 600-ohm output, and a noise and harmonic-distortion meter. A good selection of hand tools is also necessary for routine repairs.

After a few years of "chiefing" a small station, you can move up to a larger station or television if you desire. The opportunities are almost limitless. You will find out that being in charge of a small station can be one of the best training grounds in broadcasting. You will have a hand in all phases of radio-station operation, including probably a little sales, news work, and announcing, along with obtaining a good idea of how management operates. ▲

Panic Button

By PAUL FRANSON

Like to build a simple electronic siren? Here are construction details for two such units, including one with self cycling.



Internal view of the "panic button" shown schematically in Fig. 2. The entire unit can be housed in small chassis box.

OF all the electronic toys and games that have been developed, none seems to have more appeal than the "panic button" or simple siren. In its best-known form, which has been around for many years, the panic button consists of a small box with a push-button mounted on it. When the button is depressed, an oscillator is energized and, instead of producing a tone of constant frequency, the oscillator furnishes a slowly rising note much like that of a siren. The tone rises while the button is held down, then, when it is released, falls slowly and finally stops unless the button is depressed again.

How it Works

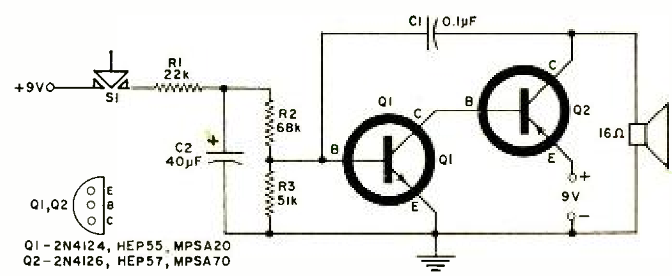
The basic circuit for producing the siren tone consists of a complementary, direct-coupled amplifier using silicon plastic transistors (Fig. 1A). Oscillation, produced by capacitive feedback (*C*1) from the output to the input, is frequency dependent on the bias current present on the base of *Q*1. When switch S1 is depressed, *C*2 is charged at a rate (time constant) dependent on the values of *R*1 and *C*2. This causes the bias current and the audible oscillation frequency to rise slowly. Likewise, when switch S1 is opened, *C*2 discharges slowly at a rate dependent on the time constant of *C*2 and *R*2 plus *R*3 in parallel with the input resistance of transistor *Q*1.

Since the transistors used in this circuit are silicon and have very low leakage, they can be left connected to the battery (standby current is in microamperes). The maximum current drain during operation is about 15 mA, so a 9-volt transistor radio battery will do for intermittent use.

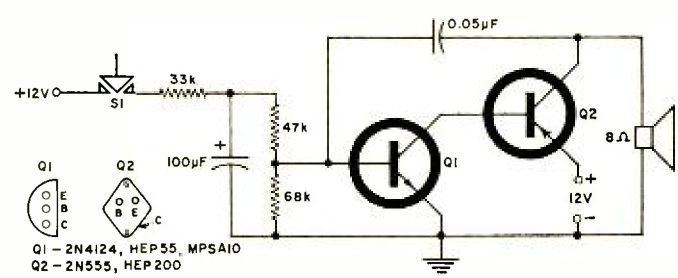
The loudest siren-like sound can be obtained using a high-impedance (up to 40-ohm) speaker, although a loud and annoying output can be obtained with an 8-ohm speaker.

A Lounder Panic Button

The schematic of a more powerful version of the panic button is shown in Fig. 1B. This is the same circuit as that shown in Fig. 1A, except the components have been changed. The *p-n-p* silicon output transistor (*Q*2) has been replaced by a germanium power transistor which, due to its lower impedance, provides greater output. In addition, since it also draws more current, this circuit should be operated from a 12-volt car battery. (*Continued on page* 62)



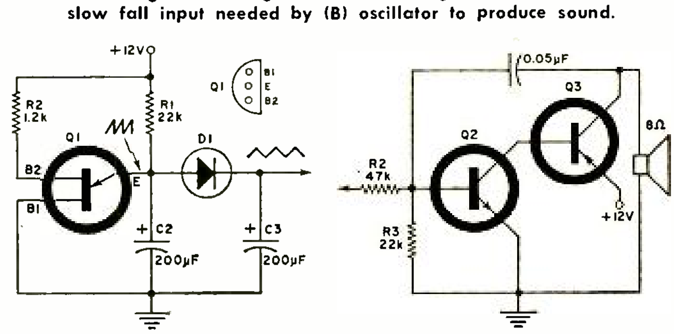
(A)



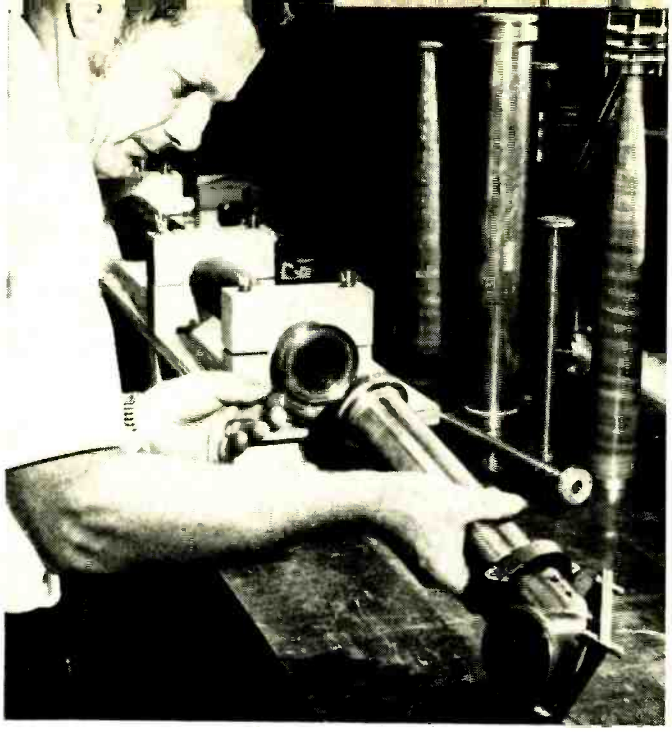
(B)

Fig. 1. Schematic diagrams of the (A) simple panic button operating off a 9-volt transistor radio battery, and (B) a louder version of panic button powered by a 12-volt battery.

Fig. 2. Schematic of the self-cycling panic button showing (A) triangular-wave generator used to generate slow rise, slow fall input needed by (B) oscillator to produce sound.



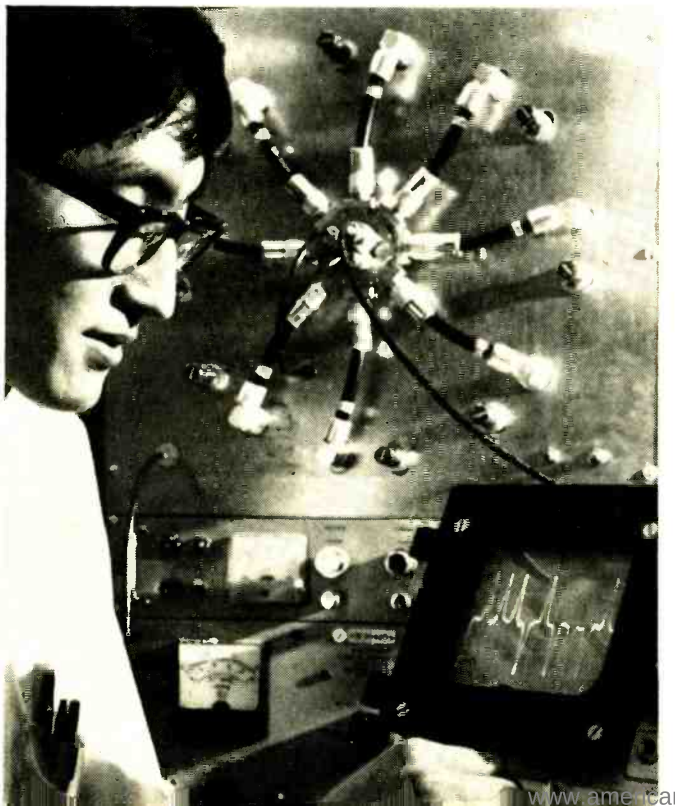
(A) (B)



Samples of the 2-in copper-lined steel waveguide, similar to the type to be used in the field trials, being checked out.

Millimeter-wave repeaters will be required every 20 miles. The components for such repeaters are now being lab-tested.

The new system will use pulse circuitry to carry audio, video, and data. Such circuits are presently under development.



WAVEGUIDES *to Carry* PHONE CALLS

By MILTON S. SNITZER/Technical Editor

Field trial is planned for use of buried circular waveguide operating in millimeter-wave region to carry quarter-million phone conversations.

A BURIED 2-in circular waveguide will be used to carry telephone signals in a new communications system planned for northern New Jersey. Components for the new system are now being developed by *Bell Labs* in preparation for a 1974 field trial. Commercial service using the waveguide system will start later in the seventies. Long-distance telephone calls, data communications, and picture-telephone signals will all be handled by the buried pipe, which will be able to carry a quarter million simultaneous phone conversations. Because of the very low r.f. losses in the waveguide, repeater-amplifiers will be required only every 20 miles for relatively straight runs. In comparison, signals traveling over present coaxial-cable lines must be amplified every few miles.

The band of frequencies to be used lies in the millimeter-wave region. These are frequencies higher than microwaves but below those of infrared light waves. The band extends from 40 to 110 gigahertz, and has a greater signal-handling capacity than all the lower radio frequencies combined. New solid-state devices, such as IMPATT diodes, will be used to generate the millimeter-wave signals.

All information, including telephone audio or picture-telephone video, will be converted into digital form using pulse code modulation (PCM). Such pulses are less susceptible to noise and distortion, are readily mixed or multiplexed, and can be regenerated more easily than smoothly varying analog signals.

Between now and the field trial, special techniques will be developed for manufacturing straight lengths of uniform waveguide. This is because any imperfections in roundness or straightness of a waveguide decrease its transmission efficiency. Methods must also be developed for burying it, with minimum bending, about four feet underground, and for installing it along gradual route bends, like those of major roads and highways. Since the straightness and roundness of buried waveguide is sensitive to even localized earth movements, the pipe will be encased in a protective conduit.

To keep waveguide losses at a minimum the circular waveguide will have two types of inner wall lining—either a helically wound, insulated copper wire or a thin layer of copper with a dielectric coating. The helical-wound guide will absorb undesired modes or field-distribution patterns, while the dielectric-line guide will slow them down, minimizing energy transfers from the desired low-loss mode. Both types of waveguide will be installed for the field trial that is planned. ▲

Novel Ultra-Low-Frequency Woofer Enclosure

By RAY DONES / President, Octavium, Inc.

Design of an unusual hi-fi loudspeaker system for frequencies below 64 Hz makes use of vibrating side panels and slot loading.

MOST of the cost, the largest percentage of the size, and a good deal of the weight of our loudspeaker systems are devoted to the reproduction of the last few octaves at the low end of the audible spectrum. Even the most massive conventional enclosure housing the largest driver with the heaviest magnet may still not be quite adequate in a system that is to reproduce the very low frequencies with the same intensity and fidelity as the mid-range and treble.

Good reproduction of the very low frequencies is most difficult to check. Response in the octave from 200 to 400 Hz of any two systems can be compared by listening, with the assurance that the output of a quality loudspeaker system will provide an acceptable replica of input waveforms. Low-distortion, high-intensity output in this range has been an accomplished fact for years. This is not true of comparisons in the octave from 16 to 32 Hz, since the intensity thus far attained is so low and the distortion so high in most cases that A-B comparisons mean little. Graphically displayed output frequently bears little resemblance to the input waveform. Since there is not much sense in comparing one highly distorted speaker system with a differently distorted one, we are left with the comparison between the original sound and the reproduction. With this comparison, the owners of most loudspeaker systems are likely to become dissatisfied, and there are two very good reasons for this dissatisfaction.

The first reason is that all speakers show a drop in acoustic output as the frequency of operation is lowered. They all fall somewhere in the three lowest audible octaves (16-32, 32-64, 64-128 Hz). The only variables are the points where the drop begins and the slope of this fall. Better quality units delay this fall to the second octave, between 32 and 64 Hz. Designers also attempt to restrict the slopes of the fall so that there is still some output in the first octave, between 16 and 32 Hz.

The second reason for dissatisfaction is also characteristic of all of the speaker systems currently marketed—an increase in distortion when the operating frequency is lowered through these lowest octaves. It has become commonplace for us to tolerate speaker systems with distortion, in some cases of 50 percent or more when reproducing low power in the first octave, when we would not accept the system that produced higher frequencies at 5 percent mid-range distortion even at high power levels.

Whenever we hear a pipe organ played in a spacious cathedral, or listen to a symphony orchestra in a good hall, or stand close by as the bass drummer passes us in a parade, or even perceive the beats between notes of a left-hand piano chord played softly in our living room, we are inspired to try to build a woofer and enclosure that will duplicate these audible sounds.

Our listening room floor is carpeted and two adjacent walls are treated with acoustical tile. This combination, in general, of a hard plaster wall or ceiling, opposite an absorbent wall or floor, gives a sort of neutral environment for the comparison of the numerous speaker systems that we have listened to critically over several years.

We tried out pairs of most of the new speakers as they became available, from multi-way cone-type units to full-range electrostatics. The treble, mid-range, and even mid-low-range reproduction of most of the better-quality pairs tested was satisfactory. We were most disappointed, however, to find that the reproduction of frequencies below 100 Hz was not audibly improved over the better mono systems that we had heard from the corner of our listening room years before. Most pairs were not nearly as good in the lower octaves as a single corner folded horn. We still could not reproduce the "feel" of the fundamental low frequencies that we experienced with live performances.

Corner speaker placement was audibly superior in our living room, as in most other rooms in which we have listened. Using two corners for stereo-speaker placement decreased low-frequency distortion slightly, since the power input to each speaker could be decreased. It did not appreciably affect the low-frequency cut-off point, however, and substantially the same rate of decay in the very low-frequency response was present when using two corners as was apparent when only one corner was utilized.

Searching for a Standard

We believe that we suffered from the same dilemma as thousands of others—as really satisfactory low-frequency performance is approached, the systems get too large for the living room. We experimented by simply mounting a group of woofers in an outside wall or ceiling of the listening room. In this way, perhaps it could be determined what size diaphragm or cone area is necessary to reproduce these low notes at an acceptable level. Vibrational amplitude would be restricted by the cone suspensions of the drivers used, but we proposed to use a group large enough so that cone motion would remain in the linear region—consequently, distortion would be low. Also, it was hoped that the cluster would have a subsonic bass resonance, so that there would be little fundamental-resonance coloration in the working range.

Since these experiments would hardly be tolerated at home, they were moved to a workshop which was roughly the same size as the living room, of rectangular floorplan, some 20 by 30 feet with a 9-foot ceiling. Over the shop was an attic of about 1800 cubic feet. The ceiling consisted of a framework that supported four-by-eight-foot removable panels of heavy acoustical Celotex. These panels were braced and covered with rock wool to maintain acoustic isolation of the attic. An alternate panel made of ¾-inch filled Novoply chip board was cut for each group of woofers to be tested in this attic "infinite baffle."

Mounting the panel containing the "woofer" in a corner of the room made a profound difference in sound output, as compared to other locations in the ceiling. So we decided early in the experiments to use this corner position whenever possible. Also, the resonant frequency of the driver was invariably lower when measured from a corner-panel location. Since the moving-mechanism of the driver and the volume of the attic "enclosure" were unchanged, this lowering of the resonant frequency could only indicate coupling to a larger air-load mass.

The most satisfactory "woofer" consisted of a group of 25 12-inch drivers that we mounted in a corner panel. These drivers had measured individual free-air resonances of from 27 to 30 Hz. The over-all resonance of the mounted group was about 13 Hz. The total cone excursion of these drivers was ½ inch, so we felt that they should be reasonably linear for the first ¼-inch of cone travel.

Listening tests of these woofers were quite revealing. The cluster was smooth and powerful and capable of reproducing the fundamentals through the first octave; and you could even feel beats between the low notes. Apparently, the superiority of the cluster was due to the larger total cone area. We felt that in the 25 12-inch drivers, "infinitely" baffled, we had found a standard for comparison.

One bonus from the use of this standard was a demonstration of the lack of directional orientation at low frequencies. We made use of 60-Hz a.c. from a bell or filament transformer to A-B check our standard against an ordinary system, which could easily be localized when driven with this 60-Hz sine wave. The direction of the standard system could not. Experiments with an oscillator at frequencies below 100 Hz confirmed this observation. With the sine waves, there seems to be no apparent direction of origin of these low frequencies. As harmonics are added to low-frequency sine waves (by the speakers or otherwise), the direction of the source becomes localized.

Stereo music and sound effects were indistinguishable with a 100 Hz or lower, 18-dB/octave crossover network, whether one woofer was fed from both channels or the standard divided into two woofers, one for each channel. Also, the location of the single woofer was not apparent; the sound seemed to emanate only from other speaker units reproducing the frequency components above 100 Hz.

Using the Enclosure Walls

The effective cone area of our standard equals the total outside surface area of a cabinet of moderate dimensions. We surmised that we would have to make use of the enclosure walls as a moving diaphragm, in order to activate the required area for good first-octave performance in a unit of acceptable size.

The stiffness of the enclosed air in a small enclosure would make the resonant frequency of a large diaphragm too high to be practical, or the high mass required for resonance in the usable range would require an inordinate amount of drive power. So we had to resort to some device to drive a large auxiliary diaphragm outside the enclosure, while working through a small orifice into the interior of the speaker cabinet.

Briefly, that is how the low-frequency reproducer (LFR), shown in Fig. 1, was devised. The four plastic-foam side panels vibrate in unison. Together, they make up a 2000-square-inch vibrating diaphragm—the same area as that of the combined driver cones used in our standard woofer. The enclosed chamber with the slot-orifice leading into a small second cavity (composed of ½-in driving ducts) is the coupling means used to transfer the energy from the driver cone to the panels. The vibration of these panels is quite intense at the lower frequencies, where they supply the bulk of the acoustic output.

The panels, in conjunction with the enclosed cavities, serve three important functions:

1. There is a phase shift of the panels relative to the phase of the bottom-mounted-driver cone. This phase-shift can be varied, that is, the enclosure can be "tuned" so that the phase-shift reaches 90 degrees at the lowest frequency to be reproduced. The enclosure-panel resonance is broadly "tuned" to the lowest frequency to be reproduced. It is at this lowest frequency of operation that we need the most help from the panels—to maintain acoustic output. We also need the "loading" effect of these panels to keep voice-coil impedance at the optimum for good power transfer and to properly control the driver cone so that excursions will remain in the linear region.

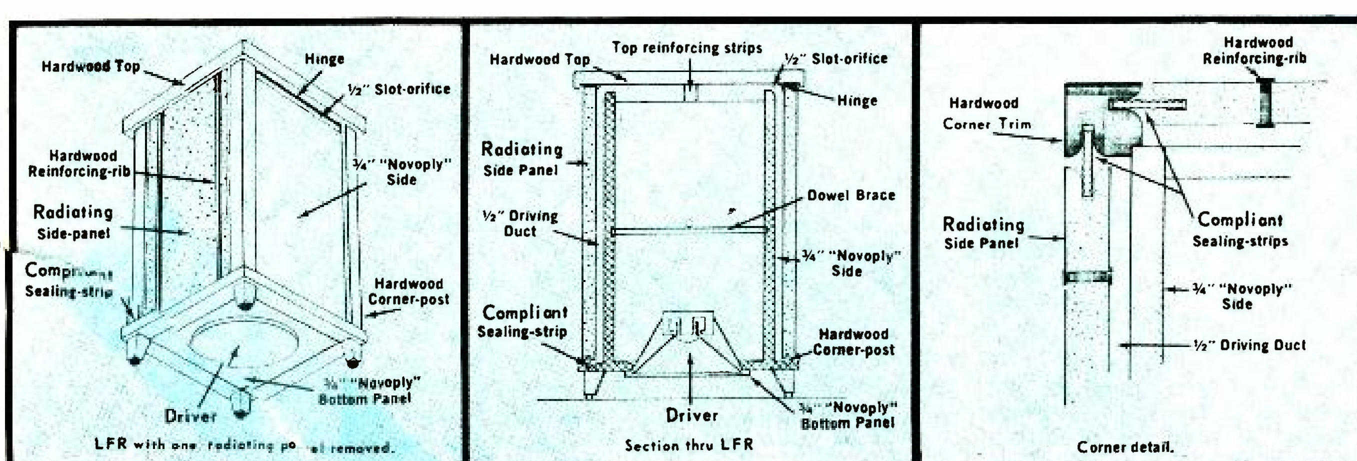
2. There is a low-pass-filter action as the restricted area of the orifice opening into the cavity allows the low-frequency vibrations to pass readily, and yet progressively restricts movement as operating frequency increases.

3. The small-area, high-velocity vibration through the orifice is converted to a large-area, low-velocity vibration of the panels in much the same way as a horn. The corner placement recommended for this enclosure has the effect of further multiplying the area of the panels.

The tuning of this enclosure is accomplished in a manner similar to that used to tune bass-reflex or ducted-port loudspeaker enclosures. The LFR has other variables besides enclosure volume and duct geometry that influence the frequency of enclosure tuning. The mass of the plastic-foam panels, as well as the effective mass of the air that they move, must be added to the mass of air in the orifice or duct. This additional mass greatly lowers the frequency of enclosure tuning. Also, the sealing strips on the sides and bottom of the panels and the top-suspension hinge have some stiffness, which tends to raise this frequency slightly. In practice, empirical methods are used for exact frequency adjustments because of a great many tuning variables.

Since the lowest musical note that need be reproduced is

Fig. 1. Construction of the low-frequency reproducer along with cross-sectional and detailed views. Four plastic-foam side panels, driven by way of a half-inch slot and duct, vibrate in unison to produce the very low frequencies.



approximately 16 Hz, which is the lower audible limit of human hearing, this frequency was selected as the design target of the LFR. Many experiments and considerable research determined the optimum relationship among cabinet volume, the orifice area, and the weight and rigidity of the closed-cell foam-plastic panels. The flexible airtight sealing strips were made as compliant as practical with available foam-rubber compounds of the necessary strength and durability. The wood rib-inserts in the panels are not for appearance alone; they prevent unwanted flexing of the panels. The particular hardwood used for inserts was selected for the best stiffness-to-weight ratio.

The compliance of the enclosed air can be modified in loudspeaker enclosures by the addition of sound-absorbent linings or fill. Absorbents also effect considerable attenuation of higher-frequency energy available to the orifice or port. Ten 3-inch cross-alternated layers of fiberglass fill are necessary for the LFR to achieve the desired characteristics.

Drivers and Crossovers

Good response curves were obtained with each of several 15-inch drivers, and tolerable results with one of the 12-inch units from the previous experiment installed in this enclosure. A high-efficiency unit with a lightweight and very rigid cone, with a long-throw voice coil and with a very low free-air resonance frequency is recommended. Drivers with added mass in their moving systems are unnecessary.

There seems to be less tendency for voice-coil rubbing with the vertical voice-coil motion utilized here, so clearance between voice coil and pole pieces could be safely reduced somewhat for increased efficiency. The free-air resonance of the driver designed for this enclosure should be made very low by making the suspension more compliant, rather than by mass added to the cone or voice-coil former. This lighter, more compliant moving system would not only further increase efficiency, but would increase the electrical damping available to the driver used with the system.

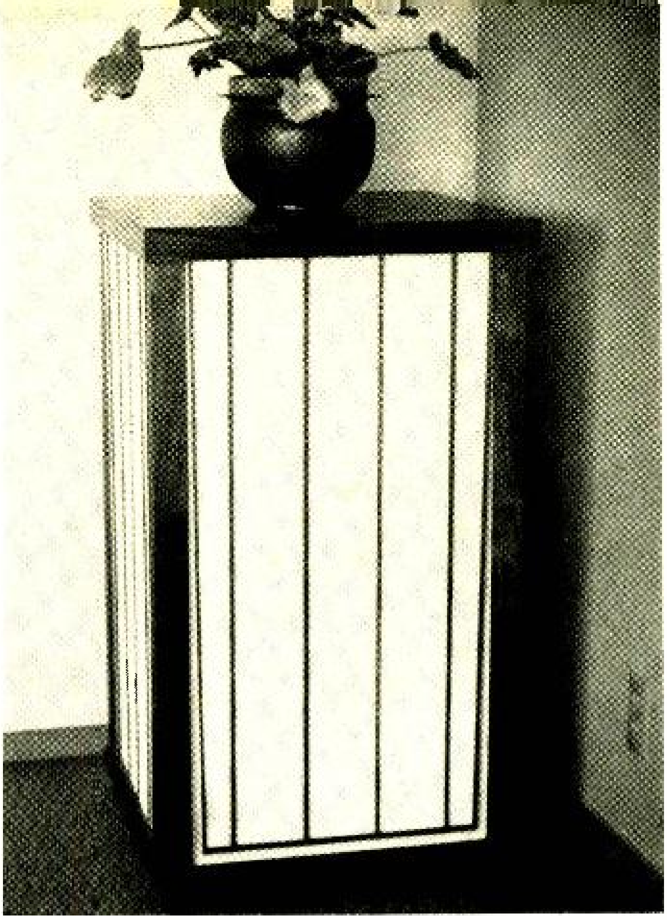
We were successful in locating a manufacturer to produce a 100-watt continuous-power-rated 18-inch driver that met the above criteria. This unit has a free-air resonance of 15 Hz, a 3-inch voice-coil diameter, and 5¼ lb ceramic ring magnet with total flux of 285,000 maxwells.

An 18-dB/octave crossover slope is the minimum that should be used with the LFR. A 64-Hz crossover frequency is used and all frequencies below this value from both stereo channels are combined and applied to a single LFR unit. Higher frequencies are fed separately to two spaced satellite speaker systems.

Although *LC* crossover networks can be used, the more sophisticated approach is to use electronic crossovers ahead of multiple driving amplifiers. With this approach, the high damping factor of the modern solid-state amplifier can be utilized to best advantage to keep the driver cone under control at all frequencies. The same crossover frequency is used with electronic crossovers as with the more conventional *LC* networks.

The impedance curve of the LFR has two humps and a valley, similar to a bass-reflex curve. The upper hump (which should occur at the 64-Hz crossover frequency) is the resonance of the driver in the enclosure. The valley (which should occur at 16 Hz) reflects the enclosure tuning or resonance of the panels working against the enclosed air of the LFR. There is also a series-resonance of the driver, panels, and effective air mass working against mechanical suspensions and resistances. This series-resonance is subsonic, occurring somewhere below 13 Hz, depending on the driver used.

The roll-off slope of the speakers used as satellites is not too critical. Most quality acoustic-suspension systems used for this purpose will be down about 3 dB at 50 and 70 Hz when mid-wall mounted, and will be a good match. Ideally, the satellite should be down 3 dB at 64 Hz measured through



Low-frequency reproducer shown in proper corner placement.

the crossover network. A few decibels one way or the other is inaudible.

We have tried several pairs of good-quality two-way and three-way speaker systems of the sealed-enclosure type, on the floor, on shelves, and hanging from the walls of our living room. We have also tried two full-range electrostatic types coupled to our low-frequency reproducer. Together with the LFR, any two of these units can reproduce sound in our living room more like the original in frequency response, intensity, and dynamic range—and with less noticeable distortion or coloration from speaker or amplifier.

How does this enclosed unit compare with the standard? They are almost identical in sound, although the LFR required approximately four times the low-frequency power for the same output. Ten watts was adequate for the standard woofer. The LFR enclosure with 15-inch driver and two satellites needs 50 watts per channel, or 100 watts total input —and this power should be available at the lowest frequency. The 18-inch unit needs 100 watts for the LFR alone.

What is its size? The prototype enclosure is 20¾″ × 20¾″ across the top; it stands 37″ high over-all. Its ideal position is on the floor, about six inches from each wall in a corner.

How much does it cost? The LFR enclosure with its 18-in driver, a separate 100-watt amplifier and crossover will cost several hundred dollars. Add to this the cost of the speakers used as satellites and you have a fairly expensive system, but one that produces excellent sound. ▲

Editor's Note: The system described above was originally planned to be marketed under the Octavium *tradename. However, the production and marketing have recently been taken over by* Elektra Amplidyne Research, Inc., *P.O. Box 698, Levittown, Pa. 19058. This company will supply details on prices and availability.*

Note also, that because of the many variables involved in the design of the enclosure as outlined in the article above, we do not recommend that our readers attempt to home-build the enclosure.

Using Power Line as Accurate Time Standard

By RALPH A. ANDERSON
Senior Electronics Development Engineer, MSI Data Corp.

Description of a technique for using power-line source as accurate 1-microsecond to 100-millisecond time standard for calibrating scopes.

DID you realize that the 120-volt, 60-Hz a.c. voltage supplied by the local electric power company can be used as an accurate, 1-microsecond to 100-millisecond time standard for calibrating the sweep of an oscilloscope?

Since electric power companies must insure that their customers' electric clocks are accurate by maintaining the power-line frequency at a constant 60 Hz (the heart of each electric clock in the home is a synchronous motor whose shaft speed is a submultiple of 60 Hz), nearly every home power source is a virtual time base.

Typically, the *Southern California Edison Company* checks the accuracy of the power-line frequency by comparing the time indication on a master electric clock with that from the NBS Time Standard Broadcast. The frequency of the voltage from the electric company's huge power generators is adjusted, as required, to insure that the time indicated by the master clock never deviates from the correct time (as indicated by the Time Standard Broadcast) by more than 2 seconds.

When the master clock shows a 2-second error, the 60-Hz frequency is shifted approximately 0.03 Hz higher or lower, as required, until the master clock again maintains the correct time. This intentional ±0.03-Hz frequency shift for time correction added to the ±0.02-Hz tolerance of the base frequency makes the nominal tolerance of the 60-Hz base frequency ±0.05 Hz (or ±0.08%).

There are less frequent, but fairly common, occurrences when an abnormal situation causes the power-line frequency to temporarily deviate from 60 Hz by as much as ±0.4 Hz (usually −0.4 Hz). When the abnormal frequency deviation is corrected, the generator frequency is still set only 0.03 Hz higher or lower than the base frequency until the resultant time error is corrected. On rare occasions, a malfunction may cause a temporary large deviation from the 60-Hz base frequency and even cause a complete power failure. It is, however, safe to assume that most of the time, the power-line frequency is within ±0.05 Hz of 60 Hz.

Fig. 1 shows a typical 60-Hz sinewave whose characteristics are such that we can use segments of this waveform as time references for very short time intervals. It is evident from Fig. 1 that when the voltage passes through zero, it rises (and falls) very rapidly. It can be shown mathematically that at and near this zero-volt crossover point, the volt-

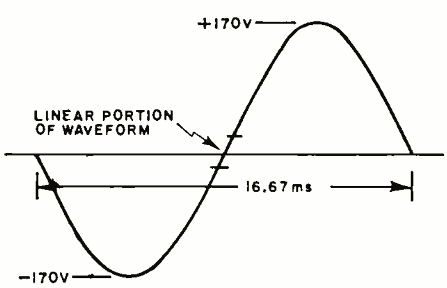


Fig. 1. Typical 120-volt r.m.s., 60-Hz sinewave showing linear portion of waveform at the zero-volt crossover point.

Fig. 2. An enlargement of the linear portion of the waveform area shown in Fig. 1.

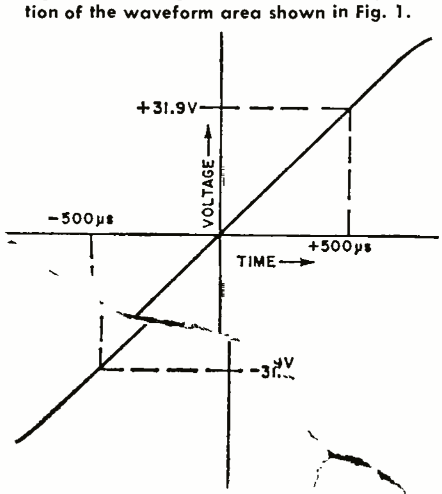


Table 1. Listing of values used when calibrating an oscilloscope to determine voltage change of 60-Hz sinewave during a specified time interval. Time measuring error for a 1-percent voltage error is also listed for each time interval.

TIME INTERVAL (T)	NO. WHOLE CYCLES	% R. M. S. VOLTAGE AT "T"	VOLT. AT "T" FOR 120-V R. M. S. SINEWAVE	TIME-MEAS. ERROR FOR 1% VOLT. ERROR
1 µs	0	0.0534	64 mV	±1%
5 µs	0	0.267	321 mV	±1%
10 µs	0	0.534	640 mV	±1%
50 µs	0	2.67	3.21 V	±1%
100 µs	0	5.33	6.40 V	±1%
500 µs	0	26.6	31.9 V	±1%
1 ms	0	51.2	62.5 V	±1%
5 ms	¼+	134.0	161.0 V	+3.32%, −1.30%
8.33 ms	½	0	0	negligible
10 ms	½+	−83.3	−100.0 V	+0.4%, −0.2%
16.67 ms	1	0	0	negligible
50 ms	3	0	0	negligible
100 ms	6	0	0	negligible

age rises (or falls) at the rate of $2\pi \times$ *frequency* $\times$ *peak voltage* each second. For a 120-volt r.m.s. (170-volt peak), 60-Hz sinewave, the voltage thus rises at a rate of 64 millivolts per microsecond.

The rate of voltage rise remains constant to within ±½% for a 500-microsecond time interval on both the positive and negative sides of the zero-volt crossover point and is represented by the linear portion of the sinewave shown in Fig. 2. As the sinewave voltage approaches its peak value, it becomes more and more nonlinear and the rate of voltage rise decreases until, at the peak of the sinewave, it ceases to rise and begins to decrease. The rate of voltage decrease follows the same pattern as the rate of voltage rise and is also constant to within ±½% for 500 microseconds on both the positive and negative sides of zero; the negative half cycle has the same rate of voltage rise and fall as the positive half cycle.

Since the rate of voltage rise (and fall) of a 60-Hz sinewave is constant for 500 microseconds on both the positive and negative sides of the zero-crossover point, the voltage change during this segment of the waveform can easily be used as an accurate indication of time.

The time interval required for the voltage to rise or fall from zero to a specific level on a nonlinear part of the waveform can also be calculated by using the formula: *Time* = *arcsine* (v/V_p) / *frequency* $\times$ 360; where v = the change in voltage during the time interval, V_p = the peak voltage, and frequency = 60 Hz.

The *arcsine* of v/V_p can be found in any table of trigonometric functions. It is not desirable to use the voltage rise during the nonlinear part of the waveform as a time indication because a small voltage-measurement error will introduce a large time-measurement error during this part of the waveform.

The 60-Hz waveform from the power generator should, theoretically, be a fairly clean sinewave, but by the time it gets to your wall outlet, it may have become noisy and distorted. This is especially true if large motors, battery chargers, welders, etc., share a line transformer common to your wall outlet. Therefore, before using the sinewave as a time standard, it is important to observe the waveform carefully to insure that large spikes, ringing, clipping, or other forms of distortion which may introduce inaccuracies in the measurements are not present.

Using Sinewave as Time Standard

Table 1 lists the voltage changes (positive and negative) of the sinewave from zero during various time intervals. Voltages are listed both in terms of measured voltage for a 120-volt r.m.s. sinewave and in terms of percent of the r.m.s. value of the voltage. The table also lists the error in time measurement caused by a 1% voltage-measurement error; this relationship is approximately 1:1 (a 1% time-measurement error for a 1% voltage-measurement error) for time intervals of less than 1 millisecond because this portion of the sinewave is nearly linear while time-measurement accuracy is more difficult to obtain for time intervals greater than 1 millisecond.

As can be seen from Table 1, 5 milliseconds after the sinewave passes through zero, the voltage has passed through its peak value and is decreasing. The waveform of this part of the sinewave is very nonlinear and, therefore, a 1% voltage-measurement error will cause a +3.32% time-measurement error. Likewise, a −1% voltage-measurement error will cause a −1.3% time-measurement error. When measurements of time intervals greater than 1 millisecond duration are required, greater accuracy will be obtained if half-cycle periods and multiples thereof (8.33 milliseconds, 16.67 milliseconds, etc.) are used as time references.

Calibration of Scope Sweep Time

The sweep time of your oscilloscope may be calibrated using either a signal of known voltage amplitude or with the calibration circuit shown in Fig. 3. The calibration circuit is used to supply a reference voltage to calibrate the gain of the vertical amplifier and allows you to make time measurements to an accuracy of better than from +2.08% to −2.78% not including reading errors and errors due to distortion introduced by the scope amplifiers. This tolerance includes ±2% for resistor tolerances, −0.7% for lack of availability of the exact required value of resistor, and ±0.08% nominal tolerance of the 60-Hz frequency.

Calibrating with Known Signal

To calibrate the sweep time of your scope using a signal of known voltage amplitude, follow the procedures listed below:

1. Calibrate the gain of the vertical amplifier by first measuring the r.m.s. voltage present at the wall outlet and then, referring to Table 1, multiply this measurement by the value of the "Percentage of R.m.s. Voltage at 'T'" corresponding to the desired "Time interval (T)" to determine the voltage change of the sinewave during this interval. For discussion purposes only, Table 1 lists the "Voltage at 'T' for 120-V R.m.s. Sinewave."

2. Using a voltmeter, determine the high side of the 120-volt line by measuring the a.c. voltage between each contact of the 120-volt outlet and the scope ground lug and connect the scope ground to the side that has the lowest voltage. *Be very careful at this time because the scope chassis may be at a higher voltage than water pipes and even earth. To avoid electrical shock do not touch the scope chassis while making these measurements.* Connect the high side of the 120-volt a.c. line to the vertical input of the scope.

3. Set the peak-to-peak or d.c. level of the calibrating voltage to the voltage level calculated in step 1 and calibrate the vertical gain by adjusting the vertical centering and vertical amplitude controls so that the deflection caused by this signal is equal to the distance from the top graticule to the bottom graticule on the scope. (If there are no graticules, mark the peak-to-peak amplitude points.)

4. Ground the vertical input and set the sweep to the bottom graticule or to some other convenient location.

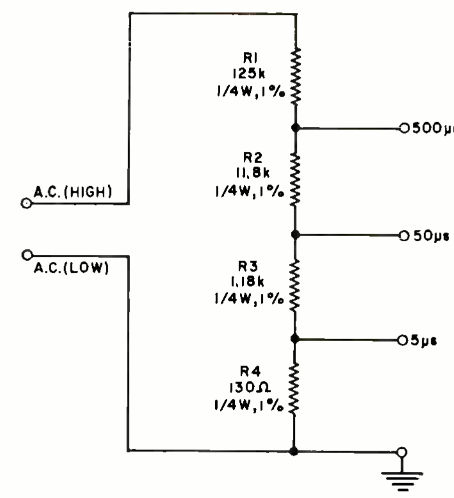
5. For fast sweep periods, set the intensity to maximum.

6. Use the 120-volt input voltage for synchronizing the sweep.

7. Set the zero-volt sweep on the bottom graticule (or bottom calibration mark) and adjust placement on the scope face with the "Sync Level Adjustment." Adjust the sweep triggering point to as near the zero volt (bottom graticule) point on the sinewave as possible.

8. Observe the voltage waveform. If the desired time interval is 500 μs or less, it should appear as a straight line. For 500 μs to 1 ms, the waveform will show very slight rounding at the upper end. If excessive (*Continued on page 64*)

Fig. 3. Schematic of calibration circuit used to supply a reference voltage to calibrate the gain of the vertical amplifier.



RCA's Solid-State Color Chassis

CTC 40

By FOREST H. BELT/Contributing Editor

Even with an advanced horizontal sweep section using SCR's, servicing problems are not unduly complicated.

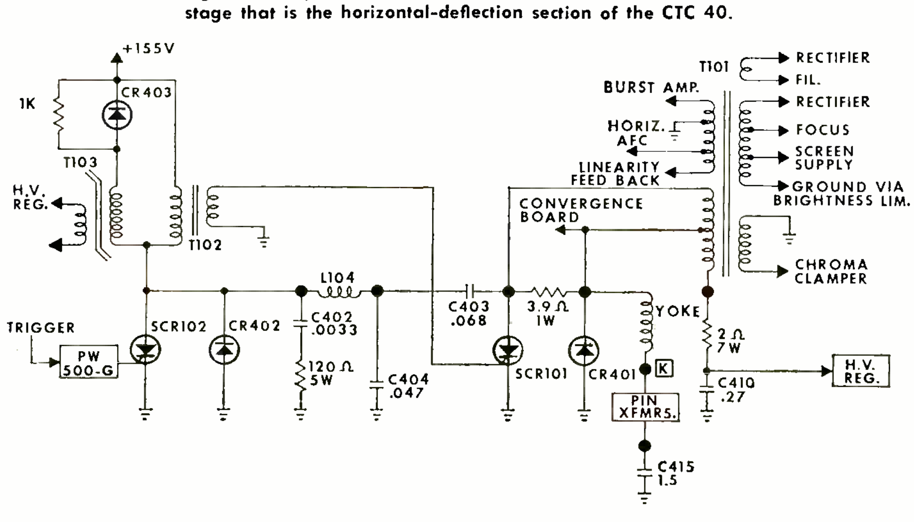
THE CTC 40 solid-state color chassis is the star of the 1970 *RCA* line. And why not? It boasts two real innovations. It has a unique color-television deflection system using silicon controlled rectifiers (SCR's) instead of transistors and the only television r.f. section with a field-effect transistor. The only tubes remaining are the high-voltage rectifier and, of course, the picture tube.

There are other things about the CTC 40 that make it interesting too, like the integrated circuits in the automatic fine tuning and sound sections and the varactor-controlled color oscillator. We'll explain some of these circuits in detail.

Silicon-Controlled Sweep

In seminars *RCA* has held around the country, the greatest interest has centered on the unique horizontal-deflection system. Prospective buyers want to know how dependable it is and technicians ask how tough it is to service. Experience has answered both queries. The SCR sweep action seems as dependable as transistor output stages (more so under some circumstances). And *RCA* recommends a procedure that makes servicing the SCR sweep stages almost cut-and-dried. The simplified schematic of Fig. 1 will help you understand how it works.

Fig. 1. A simplified version of the silicon controlled rectifier stage that is the horizontal-deflection section of the CTC 40.



A blocking oscillator, locked to horizontal sync, supplies trigger voltage that synchronizes operation of the SCR sweep section. The trigger is a positive-going spike about 15 volts peak-to-peak. It is applied *via* the PW500-G PC board to the gate of the first SCR, *SCR*102, which is the *retrace* SCR.

When the trigger gets to it, *SCR*102 fires. That starts the first half of the retrace and the beam starts back from the right side of the picture tube. The current that flows through *SCR*102 comes from energy previously stored in *C*403 and the yoke. The discharge path is through *T*101, the yoke winding, some pincushion transformers, capacitor *C*415, ground, *SCR*102, and *L*104.

The decaying magnetic field caused by this current in the yoke winding lets the CRT beams move quickly across the screen from the right side. When *C*403 is about discharged, the beams are at the center. That makes the first half of the retrace.

Resonance in this discharge path creates a flywheel effect for energy that is now stored in *C*415. It starts current flowing in the opposite direction. There is no path for the current through *SCR*102, because polarity of the new current reverse-biases it, cutting it off. However, it does forward-bias *CR*402, the *retrace diode*. Current can flow freely in the opposite direction—through the pincushion windings, the yoke, *T*101, *C*403, *L*104, *CR*402, and ground. The CRT beams are swept from the center over to the left side of the screen.

This whole retrace takes only a few microseconds. While it's happening, the CRT beams are blanked. If they weren't, they might carry some noise or other unwanted modulation that would show up between the lines of the raster. Once the retrace is completed and the beams are at the left side of the screen, the CRT is unblanked. The beams are poised to be swept across the screen to produce one line of raster. They're ready to begin the *trace* period.

During the last half of the retrace, when current is rising in the negative direction, energy is storing up in the inductors of the circuit. When voltage across the yoke gets high enough, *trace diode CR*401 becomes forward-biased and conducts. That isolates the yoke from most of the resonant circuit and lets it discharge energy directly into *C*415.

As current starts flowing out of the yoke, the magnetic field begins pulling the beams from the left side toward the center of the picture-tube screen. There is also some energy left in *L*104. It discharges through *CR*402 and *CR*401 (there's not enough reverse voltage yet to overcome the conducting condition of *CR*401). *C*403 begins to recharge. This all happens very quickly, within a few microseconds. *CR*402 becomes reverse-biased and cuts off.

The original energy from *C*403 has to be replenished. This is done by a charging circuit through *L*104 and the primary winding of *T*102 from a 155-volt d.c. supply. Neither *SCR*102 nor *CR*402 conducts now, so the charging current "fills up" *C*403. This charging occurs at the same time as the first half of the trace. When it's done, the *C*403-*L*104-*SCR*102 circuit is ready for the next retrace.

The beams are meanwhile moving from the left edge to the center of the screen. They are moved by energy that is draining out of the yoke coil through *CR*401 into *C*415. This would happen faster were it not for the charging that is also taking place using *CR*401 as part of the path. The charging is in the opposite direction from the yoke-current flow. Eventually, an equilibrium is reached. Beyond that, *CR*401 becomes reverse-biased and cuts off. Yoke energy is about gone, and the CRT beam has reached the center of the screen. Most of the energy is by now accumulated in *C*415.

Meanwhile, the charging current flowing through the primary of *T*102 has generated a pulse in the secondary. A waveshaping network that isn't shown in Fig. 1 sharpens the pulse and applies it to the gate of *SCR*101, the *trace SCR*. However, until the yoke energy is about gone and the charging voltage builds up high enough, the net voltage at the anode of *SCR*101 isn't of the right polarity; *SCR*101 can't fire yet, even with a positive gate voltage.

Eventually, *C*403 has stored up enough energy from the charging process, and *SCR*101 fires. The energy stored up in *C*415 can now discharge back the other way, through *SCR*101. Current builds up again in the yoke winding, pulling the CRT beams from the center on over to the right side. When the charge in *C*415 is about depleted, the voltage across *SCR*101 nears zero and the SCR stops conducting.

About that time, another trigger pulse gates *SCR*102, and the next retrace begins. The yoke and *C*403 are both full of energy. They start the fast discharge that makes the first half of the retrace and loads up *C*415 with fresh energy for its next exchange with the yoke.

Troubleshooting SCR Sweep

When the deflection stage is out of whack, there's no high voltage. That's the place to start checking. Put in a new h.v. rectifier tube and then disconnect the convergence board. If the circuit breaker doesn't pop open, signifying overload, there are three steps to take.

1. Check the 155-volt d.c. supply paths on the board. If the voltage is missing, check the source.
2. With your ohmmeter, test SCR101, *CR*401, and *CR*403 for shorts.
3. Substitute *SCR*102; it may be open.

One caution: When you're replacing diodes and SCR's in this stage, don't swap them around; use the part numbers *RCA* specifies. These diodes and SCR's are *not* interchangeable.

If the circuit breaker keeps tripping, turn the set off. Reset the breaker. Clip a shorting jumper between the anode (blue lead) of *SCR*101 and ground. That isolates the high-voltage transformer and the trace-producing components from the remainder of the stage. Turn the set back on. If the breaker trips again, turn off the set and use your ohmmeter to check *SCR*102 and *CR*402 for shorts. If the breaker

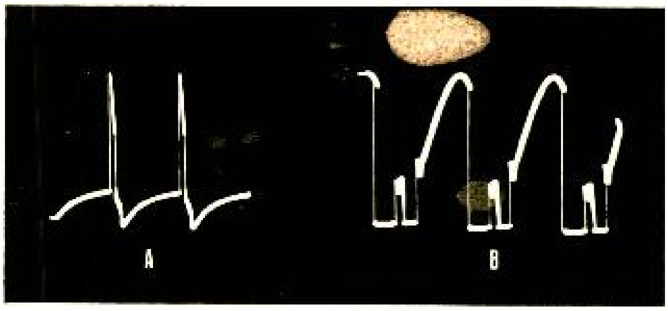


Fig. 2. Key waveforms in SCR deflection stage. (A) Trigger waveforms from horizontal oscillator. (B) Waveform at anode of SC102; pip gets taller if transformer is disconnected.

stays closed, check the focus rectifiers (not shown in figure).

Replacing the above parts does not require soldering. Any of them can be replaced in the home if you have them with you. Other procedures, for bench repairs, go deeper.

Use your scope to check the input trigger waveform (Fig. 2A) at the gate terminal of *SCR*102. If the trigger is missing or weak, disconnect the lead at the gate. A short or leak in the "*B*+" circuits can drag down trigger amplitude. If you suspect that, leave the trigger disconnected and track down the short by d.c. voltmeter.

If the trigger is okay, disconnect the high-voltage transformer. Scope the waveform at the anode of *SCR*102. The little positive-going pip along the baseline (normal waveform is Fig. 2B) should increase considerably when *T*101 is disconnected. If it doesn't, check *C*403, *C*415, and the other capacitors in the circuit (they aren't all shown in Fig. 1). One of them may be shorted or leaky.

If the waveform is normal with the transformer disconnected, then *T*101 may be at fault, or the trouble may be in one of the loads connected to it. Reconnect the transformer; then disconnect the various load branches, one at a time, to track down the bad one.

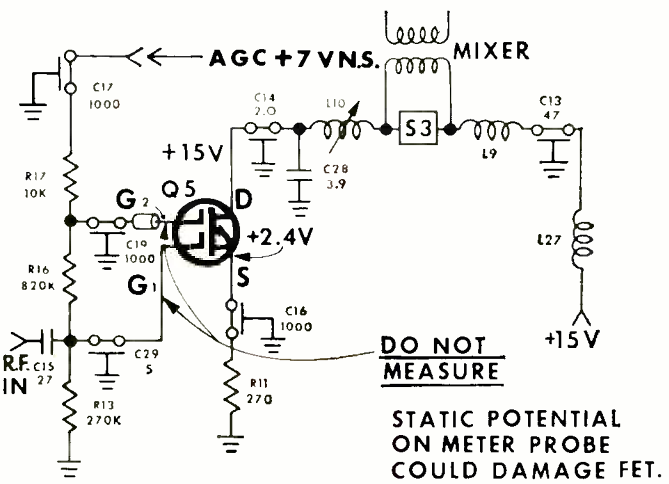
Field-Effect R. F. Stage

A transistor v.h.f. tuner isn't in itself unique. But one that uses a field-effect transistor is. The KRK142 tuner has a metal-oxide-silicon field-effect transistor (MOSFET) r.f. amplifier. This is a special MOSFET; it has *two* insulated gates.

The MOSFET gives the tuner some outstanding characteristics. Gain in the r.f. stage is high, thermal noise is low, and the chance of crosstalk—a natural bugaboo of transistor r.f. amplifiers—is exceptionally small. On the screen, you see a cleaner, more snow-free picture from weak stations and no interference patterns when there's more than one strong station (or powerful FM station) nearby.

Fig. 3 is a simplified diagram of the r.f. amplifier. The station signal is applied to gate 1, with *R*13 the input load.

Fig. 3. R.f. stage using dual-gate MOSFET. Gate 1 is the r.f. input gate, while gate 2 serves as control for a.g.c.



This gate controls source-to-drain current in the FET channel; that's what amplifies the r.f. signal.

Gate 2 is primarily a d.c. control element. The a.g.c. voltage is applied to it through *R*17. This voltage controls average channel current and sets the over-all r.f. gain the FET produces. A small part of the a.g.c. voltage reaches gate 1 through *R*16; it affects gains, but only slightly.

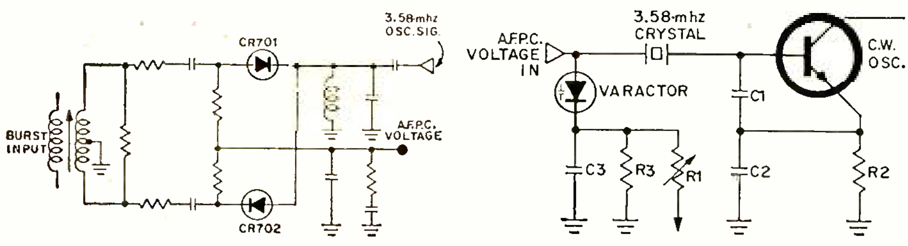
The a.g.c. for the KRK142 ranges from −5 volts on a strong station to +7 volts with a weak one or no signal. That's the limit of d.c. voltage on gate 2; the voltage stays within a volt or two of zero on gate 1.

Despite its performance advantages, the MOSFET creates a need for extra caution from a technician servicing the tuner. A MOSFET is particularly susceptible to gate puncture by any static voltage. There is a certain amount of protection built into this one—in the form of an internal zener junction—but the technician needs to be aware of certain damaging habits, anyway, before he begins his troubleshooting.

For one thing, never measure gate voltage with a v.o.m., v.t.v.m., or t.v.m. You can be almost sure static on the probe of an ordinary meter will puncture one of the gates. You won't even know when it happens. You just touch the probe to the connection and the gate is gone. The right way to measure gate voltage is back along the a.g.c. line. If a gate is already punctured, it drags the automatic gain control voltage down drastically.

If the MOSFET has to be replaced, you can damage the new one before it's even turned on if your soldering gun or iron has any a.c. field on the tip. To be safe, clip a shorting jumper between the tuner frame and the gun tip while you're soldering.

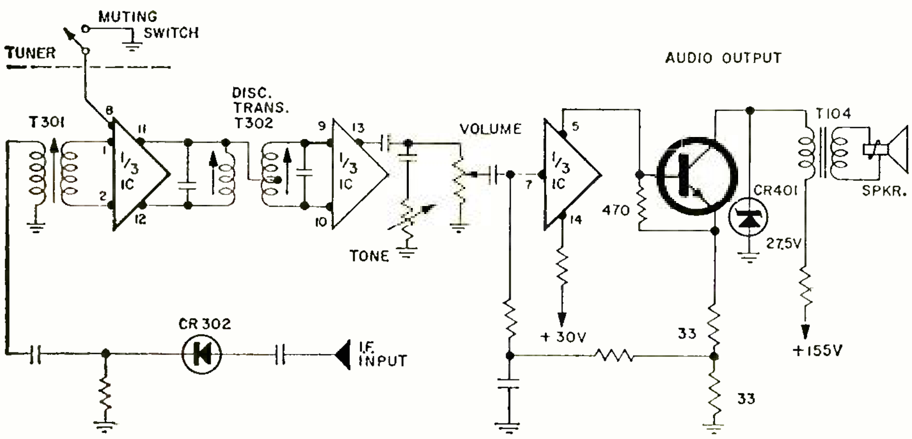
Incidentally, the diagram shows a small ferrite bead on the gate-2 lead. It helps block r.f. energy from the gate. (Some strong fields are radiated from the horizontal sweep.) It is especially important if the receiver happens to be operated in the vicinity of a powerful broadcast or ham transmitter. Whenever a MOSFET is changed, this ferrite bead must definitely be put on the gate-2 lead of the new one.



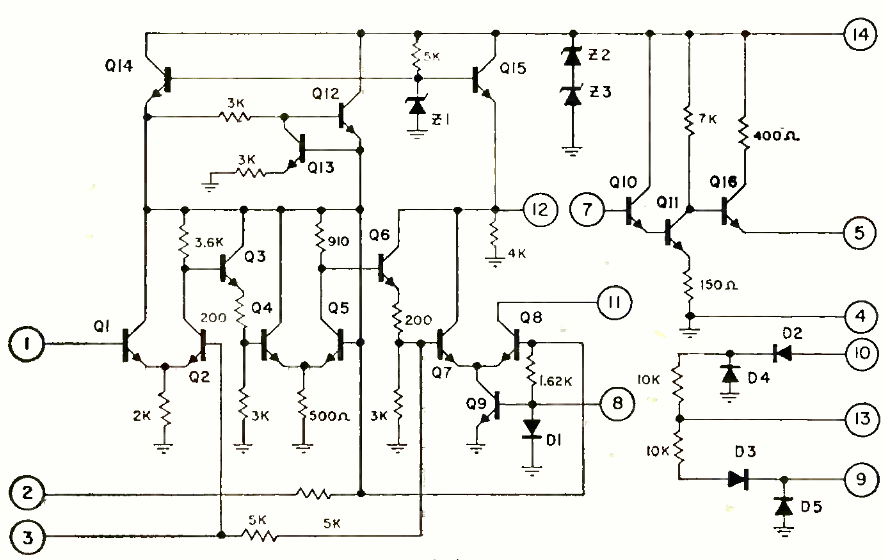
(A) **(B)**

Fig. 4. A.f.p.c. detector (A) produces a d.c. correction voltage used to control c.w. oscillator through varactor (B).

Fig. 5. Integrated circuit in sound section. (A) How it fits into the circuitry. (B) The stages that are inside the IC.



(A)



(B)

Varactor Color Oscillator

A varactor-controlled color oscillator makes possible simple and efficient control of phase in the 3.58-MHz color oscillator. The key component is a varactor diode, which exhibits the qualities of a capacitor when backward biased. Capacitance varies with the amount of d.c. bias.

As in other *RCA* color chassis, a pair of diodes in the automatic frequency and phase control (a.f.p.c.) stage produces a d.c. voltage that, in one way or another, locks the frequency of the color oscillator in phase with the transmitter color-sync burst. The a.f.p.c. stage of the CTC 40 is shown, simplified, in Fig. 4A.

The c.w. oscillator is a transistor version of the Clapp. It is shown in Fig. 4B, with the control varactor.

Frequency of the oscillator is controlled mainly by the 3.58-MHz crystal. However, the precise frequency and phase of the crystal depends on capacitive loading by the varactor. (*C*3 is a comparatively large-value capacitor that decouples the varactor from d.c. bias divider *R*1-*R*3, and holds its cathode at signal ground.) *R*1 supplies bias for the varactor, setting a nominal capacitance value.

The a.f.p.c. voltage applied to the varactor anode determines the precise capacitance value of the varactor. As the voltage varies, because the a.f.p.c. stage senses a slight phase difference between incoming color sync and the c.w. oscillator output, capacitance of the varactor varies with it. Loading on the crystal is changed just enough to correct the phase error.

Integrated Circuits

The sound section has an integrated circuit that is a bit more complex than in earlier *RCA* chassis. This one has an audio preamplifier in it, in addition to

(*Continued on page* 61)

MATHEMATICS
with a Light Touch

The electronics technician must make peace with the ogre of mathematics or abandon all hope of advancement in his field.

By **John Frye**

BARNEY was never one to surrender willingly a single minute of his lunch hour; so Mac, his employer, was mildly surprised to return from his lunch and find the redheaded youth sprawled at full length on the service bench munching an apple and glowering at a bunch of figures he had written on a yellow scratchpad in front of him. A little paperback book lay at his elbow.

"Ah he's improving his little mind!" Mac exclaimed with syrupy approval. "Whatever can he be studying: the gas mileage he's getting out of his hotrod? figuring up where last week's paycheck went? or is he trying vainly to find a positive correlation between his girl friend's vital statistics and those of Raquel Welch?"

"If you *must* know," Barney said, heaving himself to a sitting position, "I'm trying to solve a very tough math problem in this little book of 'Problematical Recreations' issued by *Litton Industries* of Beverly Hills, California. A problem is featured each week in some of the manufacturer's advertisements where they have been appearing ever since January, 1957. Ever so often *Litton* compiles a batch of the brain twisters in a little book, such as this one, and sends it free to those who request it. Believe me: the problems are tough, which is easy to understand since most are contributed by engineers and technicians who work with math all day long. But I like to whet my brains on the problems, and the fact they've been appearing regularly for so many years shows that other technicians like to fool around with math, too. There's something about playing with mathematics that seems to make having to work with it less scary."

"I'm glad to hear you testify," Mac said, going to the cupboard and taking out what looked like a chubby blue book. "I've been trying to screw up my courage to spring this on you for some time; and now you've just admitted you like to 'play' with math, the time is ripe."

" 'Wff 'n Proof, The Game of Modern Logic by Layman E. Allen,' " Barney spelled out the inscription on the cover. "What the heck is that?"

"It's pronounced 'Woof 'n Proof,' " Mac answered, "and it's a game growing out of research on the Accelerated Learning of Logic project at Yale Law School under a grant from the Carnegie Corporation of New York aimed at developing materials for teaching mathematical logic to elementary school students." He opened the "book" and revealed it was really a hinged case containing a thick paperbound instruction book and a Styrofoam sheet in which were nested eighteen red and eighteen blue die-shaped plastic cubes. Each of nine cubes of each color carried the capital letters C, A, K, E, R, and N on its six faces. Each of the other nine of each color carried the lower case letters o, p, q, r, s, and i on its faces. Another nest in the Styrofoam held a one-minute timer of the glass trickling-sand type.

"That thick instruction book looks pretty ominous," Barney observed. "How do you play the game, and what's a 'Woof'?"

"A WFF is a 'well-formed formula,' an expression used in propositional calculus, a branch of symbolic logic," Mac explained, obviously quoting. "If you think of propositional calculus as being a language, then a WFF is roughly equivalent to what a sentence is in English prose—except that in propositional calculus you have explicit rules for what constitutes a well-formed formula.

"According to this game there are just three acceptable symbols for a WFF: (1) a 'p', 'q', 'r', or 's'; (2) a two-unit expression in which the first unit is an 'N' and the second is a WFF; or (3) a three-unit expression in which the first unit is a 'C', 'A', 'K', or 'E' and the second and third units are WFF's. For example, these are all WFF's: p, Np, C-p-Np, Kqr, A-s-Kqr. On the other hand the expressions o, pq, sN, and pNs are not WFF's because they do not constitute any of the three acceptable symbols."

Barney looked up from the pad on which he had been scribbling down the combinations as Mac talked. "I get the idea—I think," he said with some hesitation, "but how do you get a game that elementary school kids can play out of that?"

"There are actually twenty-one games of Wff 'n Proof of increasing difficulty you can play with this set," Mac replied; "but let's just talk about the first and simplest—the one the author says a six-year-old can master—called Shake-a-Wff. A prescribed number of capital letter and lower case cubes are shaken and thrown by a player just as are dice. Then he tries to make the longest possible WFF out of the letters showing. When he feels he has done so, the other players have an opportunity to challenge his arrangement, either on the grounds it is not a proper WFF or is not the longest possible WFF. Rewards and penalties are applied. As you can see, it's a sort of scrabble with logic symbols being used in place of words.

"But that brings me to a very interesting application. Statements can be equated to the lower case letters, and the capital letters can stand for 'connectives' of these statements. Let me show you: Suppose we set up the following sentence symbols: p means 'Boys like music'; q, 'Girls like music'; r, 'Boys like to dance'; s, 'Girls like to dance.' Then let C mean 'if-then'; A, 'or'; K, 'and'; E, 'if and only if'; and N, 'it is not so that.' Now Kpr means 'Boys like music and boys like to dance.' Cqs means 'If girls like music then girls like to dance.' CNpNr stands for 'If it is not so that boys like music then it is not so that boys like to dance.' "

" 'Hold it right there!' as Matt Dillon says," Barney interrupted. "I can see what you're driving at, and I'm fascinated by the possibilities; but this is not the sort of thing I can soak up by hearing—or even reading—it once. Let me take that instruction book home with me tonight, and perhaps we can have a rousing game of Wff 'n Proof tomorrow."

"Is this a closed discussion, or can a poor dumb female get in?" Matilda, the office girl, asked from the doorway where she had been standing unobserved for the past few minutes.

"You're as welcome as spring flowers," Barney said promptly, "but don't you find this conversation boring?"

"Not since I started reading this," Matilda said as she perched herself on a service bench stool and held up a book she had been concealing behind her back.

"'Maths for Those That Hate It by Roy Hartkopf,'" Mac read off the cover. "So that's the book you've been sliding into a desk drawer every time I walked past lately. I figured it was a James Bond novel. It's an intriguing title anyway."

"That's what hooked me on it in the first place, but it's actually a lot of fun to read and was obviously fun to write. The author's amusement bubbles up through every page. Mr. Hartkopf is an Australian, and the book was printed at *Griffin Press* for *Rigby Ltd.* in Adelaide. It gives the average person, in simple non-technical language, a basic understanding of some of the more practical aspects of mathematics while keeping him—or her—delightfully entertained.

"Mr. Hartkopf starts out by saying the average person has a vague idea mathematics is one of the few arts or sciences which combine universal general truths on the one hand with complete accuracy on the other; then he proceeds to blow this misconception sky-high. He argues that math is not so much a science as a language of size and quantity. As such, math has all the ambiguities, lack of clarity, and other shortcomings which can be found in any language.

"For example, mathematics has several 'dialects,' and in each dialect the mathematical symbols have their meanings changed just enough to make things thoroughly confusing but not enough to make it easy to see there's been any change at all. For example, three feet times three feet yields nine square feet, but three cows times three cows does not give us nine square cows! Hartkopf tells a story of a man, tired of a hole in the road in front of his house, who tied a rope around the hole and dragged it away and dumped it into a quarry—a hole so much bigger that the addition of the hole from the road made no noticeable difference; so no one ever did find where the hole in the road went. If you think this story is silly, Hartkopf suggests you consider the generally accepted theory of traveling holes in transistors. You're not supposed to ask what happens to the hole the traveling hole leaves when it moves!"

"I think I like this guy," Barney said with an appreciative grin. "How's about lending me the book when I finish with Wff 'n Proof?"

"Gladly, but I want to look at that game, too. Hartkopf talks quite seriously about graphs and then follows this with a chapter entitled '. . . And Rackets' in which he shows you can prove almost anything with graphs and statistics. For example, he shows how you can apparently prove the number of deaths in a community is directly tied to the number of doctors living there. You can get an idea of the contents of this chapter from the Disraeli quotation at the head: 'There are lies, damned lies, and statistics.'

"Don't get the idea the book is all jokes," Matilda concluded. "It's not. From it I gathered my first clear understanding of 'operator *j*,' which Hartkopf calls the 'abominable snowman of mathematics,' and of what calculus is all about. He also has puckish chapters on logarithms, rate of change, trigonometry, and abacus automation that makes you laugh and think—really think."

"A most interesting conversation," Mac commented. "All three of us have been studying mathematics, but each in a different way: Barney working with math puzzles, Matilda reading an amusing book on the inconsistencies of mathematics, and I learning to play a game in which math and logic are intermingled. The common factor is that all three have been 'playing' with math—working with it chiefly for our own amusement.

"The modern technician still has to down the castor oil of mathematics. A single glance at some of those CET tests currently running in ELECTRONICS WORLD should convince him of that. But think how lucky he is that today there are so many different and pleasant ways in which he can acquire an understanding of and an easy familiarity with this most essential and rewarding subject!" ▲

SEMICONDUCTOR, IC SALES SURGE

ACCORDING to the EIA's Marketing Services Department, total U.S. factory sales of semiconductors amounted to $1.263 billion during the first eleven months of 1969. Total sales for the January-November 1969 period increased 18.7% over the $1.064 billion sales level during the same 11-month period in 1968.

Digital and linear monolithic IC sales totaled 224.7 million units with a value of $371.7 million during the period, up 88.1% and 34.5%, respectively, from unit and dollar sales during the first eleven months of 1968.

A recap of factory sales, in millions of units and dollars, is shown in table below. ▲

Description	1st. 11 Mos. 1969 Units	1st. 11 Mos. 1969 Dollars	1st 11 Mos. 1968 Units	1st 11 Mos. 1968 Dollars
Digital IC's	194.7	308.3	103.6	225.2
Linear IC's	30.0	63.4	15.9	51.1
Hybrid IC's	121.1	69.6	95.0	57.7
Total IC's	**345.8**	**441.3**	**214.5**	**334.0**
Discrete Devices	2,979.5	821.8	2,316.8	729.9
Grand Total	**3,325.3**	**1,263.1**	**2,531.3**	**1,063.9**

SLIDE RULE as a Frequency Calculator

By LEE R. BISHOP

THE slide rule becomes a frequency calculator when its slide is withdrawn, turned end-for-end and reinserted so that the "D" and "B" scales are adjacent and 2.53 on the "B" scale is aligned over one of the "D" scale corner indexes. *LC* products then appear on the "B" scale over corresponding frequency values on the "D" scale. For convenience, *LC* products are taken with the inductance in microhenrys and the capacitance in picofarads. The "D" scale encompasses a 10:1 frequency range while the "B" scale handles a 100:1 *LC* product spread. The decimal point is located by recalling that 253 is the *LC* product for 10 MHz. Any other decimal placing can be referred to this value by counting up or down the "B" scale.

As a practical example, assume that the *LC* product for 5 MHz is desired. Set 2.53 on the "B" scale over the right corner index of the "D" scale. Run the cursor until it is over 5 on the "D" scale. Directly above on the "B" scale is the *LC* product. The decimal point is placed by taking the right index of the "D" scale as 10 MHz and counting up from 253. Here the *LC* product is 1018.

As a second example, assume that it is desired to find the frequency corresponding to a given *LC* product of 98.7. Set 2.53 on the left end of the "B" scale over the left index of the "D" scale. Take the left index of the "D" scale as 10 MHz with its *LC* product of 253. Moving the cursor right from 253 to 98.7 shows 16 MHz to be the frequency corresponding to the *LC* product of 98.7.

A little practice will demonstrate most convincingly that this method is both simple and a real time saver.

For the mathematically curious, the 2.53 is arrived at by rearranging the basic resonance equation to solve for *LC*, ($LC = 0.0253/f^2$). This equation for *LC*, the product of a constant and a variable, would be ideally suited to the slide rule if an inverse square scale existed. As such a scale does not exist, use is made of the fact that any slide-rule scale may be made into its inverse by turning it end-for-end. As the "B" scale is proportional to the square of the "D" scale, slide inversion provides a scale inversely proportional to the square of the "D" scale. ▲

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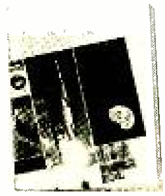

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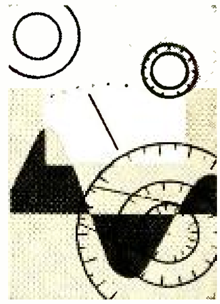


TEST EQUIPMENT

Product Report

Sencore Model FT155 FET Tester

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

MORE and more field-effect transistors are finding their way into electronic equipment. The technician who must troubleshoot and repair this equipment should have some means of testing these FET's. It is true that a good many of the newer transistor testers are able to check FET's, but many transistor testers, particularly the older models, cannot be used for this purpose.

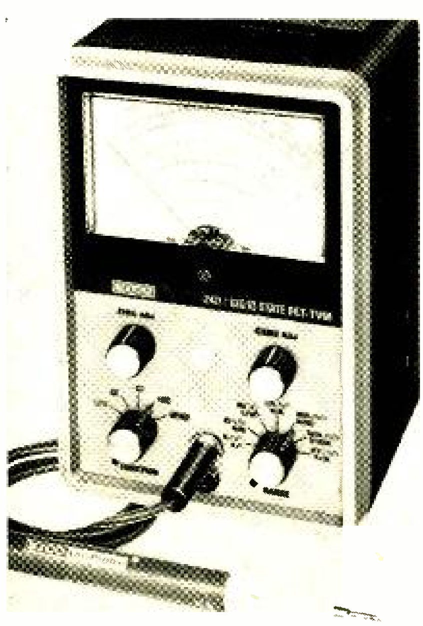
The new *Sencore* FT155 FET tester is designed to meet this need. Its use is not limited to the TV service technician; industrial technicians and engineers who are working with FET's will also find the instrument useful.

The tester checks both *n*-channel and *p*-channel FET's, including those with single and dual gates. Junction types as well as insulated-gate types are covered. The transistors are checked either in or out of the circuit for transconductance (G_m). There are two G_m ranges, 5000 μmhos and 50,000 μmhos. FET's are also checked for gate leakage current (I_{GSS}) up to 5000 μA, as well as zero bias drain current (I_{DSS}) up to 50 mA.

The indicating meter is a 6-in unit so that it is easy to read. The tester is a.c.-operated and is built into a steel case with a carrying handle. Measurements are 9½-in high by 7½-in wide by 6-in deep. The mechanical design is identical to the company's earlier Model TR139 that checked transistors only, so that the new FT155 can be added as a companion unit. Price of the new tester is $94.50. ▲

Eico Model 240 FET T.V.M.

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



JUST about all the test-equipment manufacturers have converted their old standard 2-tube vacuum-tube voltmeters into solid-state versions. *Eico's* transistorized voltmeter (t.v.m.) is the Model 240, which can measure a.c. and d.c. voltage as well as resistance, just like the old v.t.v.m.'s. If you are interested in measuring current as well, for an additional $10 for the kit or $15 for the wired unit, you can get the *Eico* Model 242. The older v.t.v.m.'s are still in the company line, but at lower prices than the solid-state units.

The Model 240, which we checked, operates either from the a.c. power line or from the built-in battery supply. The meter has 7 d.c. voltage ranges, 7 a.c. voltage ranges, and 7 ohmmeter ranges. The lowest voltage range is only 1-volt full-scale so that the very low voltages found in transistor circuits can be easily measured.

The circuit, shown here, consists of a differential amplifier formed by a pair of silicon transistors, Q2, and Q3. If both transistors are matched, and the same base bias is applied to each, the same voltage will exist at both emitters, and the meter will read zero. The base current of Q3 is kept constant by the voltage divider consisting of *R*20 and *R*21. Transistor Q2, however, uses a bias voltage divider consisting of an FET as a voltage-variable resistor, in series with *R*17.

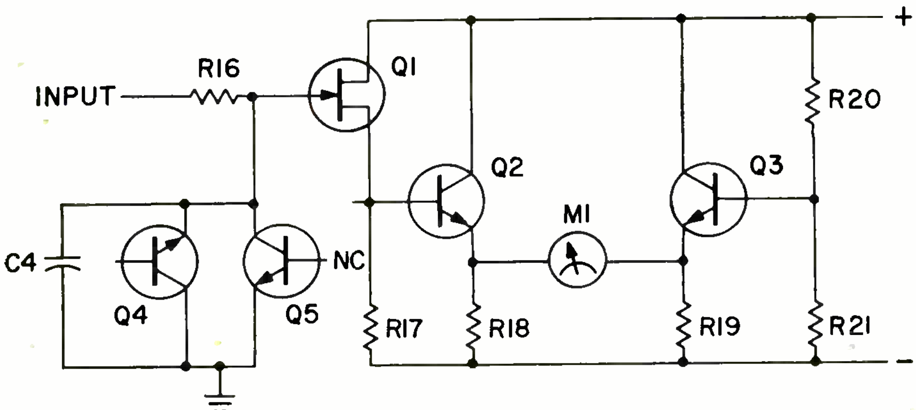
When a d.c. voltage is applied to the FET gate, its channel resistance varies and changes the bias on Q2. This changes the current through Q2, alters the voltage drop across *R*18, and causes the meter to read. The FET has a very high impedance, which is desirable for voltmeter applications.

Because too great a voltage swing at the gate of the FET can burn it out, some form of voltage limiting is required. This is accomplished by silicon transistors Q4 and Q5, which operate as back-to-back temperature-compensated zener diodes (the bases are not used). These clamp the FET gate voltage to plus or minus 9 volts.

The rest of the circuit is conventional, with resistor dividers used to permit the proper voltages to be fed to the FET for the various ranges. A pair of silicon diodes, in a peak-to-peak doubler circuit, act as rectifiers to convert input a.c. voltages to the d.c. required to operate the FET.

The meter uses a ten-turn ball-bearing pot for the zero adjustment. This permits a much finer adjustment than the conventional control. A zener voltage regulator is used to keep the instrument accurate if the a.c. power line or the batteries change voltage during operation.

Price of the Model 240 is $59.95 in kit form, or $79.95 wired. ▲



Measurements Model 940 Intermodulation Meter

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

We have always felt that a measurement of the IM distortion of a hi-fi amplifier is important. As a matter of fact, such distortion is frequently a more sensitive indicator of the quality of an amplifier than is a harmonic-distortion reading. In our lab-tests of amplifiers and receivers, we usually check the IM as well as the HD in reporting on new audio equipment.

A new laboratory instrument for measuring IM distortion has recently been brought to our attention. This is the Model 940 IM meter from *Measurements* (Div. of *Thomas A. Edison Industries*). This instrument permits direct reading of intermodulation distortion using either a 1:1 or a 4:1 low-frequency to high-frequency mix ratio. There is a choice of either 60 or 120 Hz as the low frequency while three high frequencies, 3 kHz, 7 kHz, or 12 kHz, are provided. All frequencies are generated by the instrument.

The analyzer section of the meter receives the mixed signal from the equipment under test, removes the low-frequency test signal, then amplifies and rectifies the remaining high-frequency carrier. A low-pass filter is then used to remove the high-frequency carrier, leaving only the frequency component resulting from intermodulation in the equipment under test. A direct-reading meter indicates the percent of IM and measures the input voltage to the analyzer.

The meter has four ranges, measuring 1, 3, 10, and 30-percent IM full-scale. The residual IM is less than 0.025 percent, which is about 20-dB below the lowest limit of IM found in most high-quality audio amplifiers.

The instrument is self-contained, is a.c.-line operated, and is completely solid-state. Dimensions are 14½ in by 9½ in by 7½-in deep. The Model 940 sells for $475. ▲

A Simple Linear Laboratory-Quality OHMMETER

By RONALD L. CARROLL

Use this simple unit in any critical circuit work, especially in cases where resistors must be matched.

QUITE often, when working on a critical circuit, it becomes necessary to know a particular resistance value more closely than we are able to read it on a conventional v.o.m. This is especially true in trying to match resistors. There are three basic reasons why it is difficult to obtain accurate resistance measurements on a standard v.o.m.

1. There are generally three or more decades of resistance covered on each resistance scale. The higher values are useful for "ballpark" numbers only on any given scale.

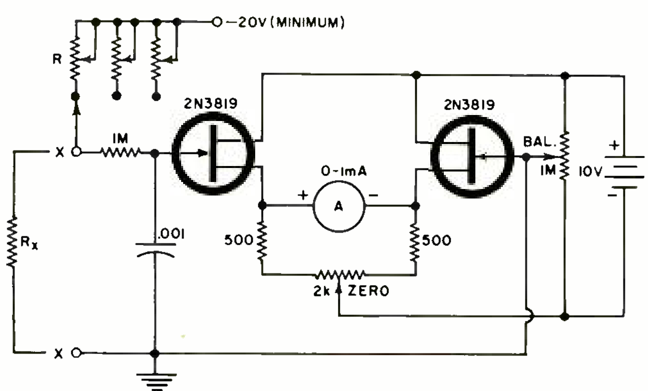
2. It is not possible to change scales without re-zeroing.

3. Low resistance values require considerable current from the v.o.m. supply in order to measure low *IR* drop elements. This has a twofold affect on accuracy. The high current heats the unknown resistor and simultaneously the battery voltage will gradually begin to fall.

If the circuit shown below is built, using rectified transformer outputs for the 10-V and (at least) 20-V supplies, it will make an excellent linear ohmmeter.

Once the indicated *R*, *Zero*, and *Bal.* pots are set, they need not be touched again. Front-panel control need only include R_X range switch. Resistor heating is kept to a minimum. Calibration is performed by adjusting *R* for full-scale deflection when the desired value of R_X is connected to the input of the ohmmeter. ▲

This simple circuit, which needs no adjusting after initial setting, is good linear ohmmeter.



R	R_x (FULL SCALE)
200-500	10
2k-5k	100
20k-50k	1k
.2M-.5M	10k
2M-5M	100k
20M-50M	1M
$2\text{-}5 \times 10^8$	10M
$2\text{-}5 \times 10^9$	100M

RCA Color Chassis

(Continued from page 50)

the discriminator and sound i.f. stages. How the IC is used is diagrammed in Fig. 5A; what's inside it is in Fig. 5B.

Terminals 1 and 2 apply 4.5-MHz sound i.f. to a differential amplifier in the IC. Output to the discriminator transformer is taken between terminals 11 and 12. Terminal 8 of the IC goes to a muting switch in the tuner of remote-controlled models. During channel changing, the muting switch closes and disables the i.f. output stage in the IC.

Terminals 9 and 10 apply the signal to a bridge-type discriminator with four diodes. The discriminator output, which is the TV audio, is taken—single-ended—through terminal 13.

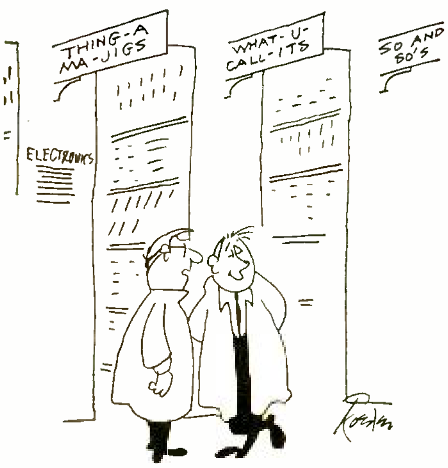
Following the volume control, audio is applied to terminal 7. It is amplified by a two-transistor cascade amplifier, then coupled out by an emitter-follower to terminal 5. From there, the audio signal drives an output transistor.

D.c. power for the amplifiers in the IC is applied through terminal 14. A pair of zener diodes, and a series transistor regulator with zener reference, hold the d.c. voltages constant inside the IC.

There's another integrated circuit in the CTC 40, in the a.f.t. section. The input for the section is a video i.f. signal. Tuned circuits pick out only the 45.75-MHz picture i.f. carrier and apply it to a pair of terminals in the IC. Differential amps in the IC amplify it.

Amplified 45.75-MHz signal is fed from the IC to two discriminator coupling coils. The a.f.c. control voltage, which is d.c., is taken between two other terminals of the IC. In the v.h.f. tuner, the voltage is applied to a transistor whose junction capacitance helps tune the oscillator.

A timid technician may hesitate to tackle the CTC 40. He shouldn't. The transistors and their circuits are no more complex than in any transistor TV. ▲



"Your parts marking system, Sneed, leaves a lot to be desired!"

Panic Button

(Continued from page 41)

For best results, the bias supply network was modified. The values shown in Fig. 1B seemed optimum with the components used.

The standby current is about ½ mA; still low, but far more than the all-silicon version. A separate switch can be included to disconnect the battery from the circuit.

Self-Cycling Circuit

Both of the circuits discussed above suffer from one disadvantage—the push-button must be depressed and released for each cycle of sound. An obvious improvement would be automatic cycling and one way to do this would be to replace the push-button by a timer-controlled latching relay. Another method would be to use an astable multivibrator or flip-flop to generate a long pulse of voltage, followed by a period of zero output, that can be applied to the input in place of the switch.

However, the approach used here was to eliminate the time-delay capacitor and resistor and apply the output of a triangular-wave generator (Fig. 2A) to the input of the oscillator circuit. The rise and fall of voltage at the output of the triangular-wave generator provides the proper bias current for the siren sound.

The triangular wave is derived from a unijunction relaxation oscillator that generates a sawtooth voltage waveform. The UJT relaxation oscillator (*Q1*) acts like a neon-bulb oscillator and does not conduct until the voltage on its emitter reaches a critical (peak-point) value. The length of time required for this to occur is dependent on the time needed to charge capacitor *C2* through resistor *R1*. When the proper voltage is reached, *Q1* conducts, discharging *C2*; and when the voltage across *C2* drops below the critical value, *Q1* stops conducting, starting the cycle over again. This repeated cycling produces a sawtooth voltage at the emitter of *Q1*.

To adapt the sawtooth waveform generated by the UJT to the slow rise and slow fall needed to produce an authentic siren sound, diode *D1* and capacitor *C3* (Fig. 2A) are added to the relaxation oscillator. The diode is forward-biased (conducting) during the period when *C2* is charging so that *C3* charges at the same slow rate as *C2*. It is this slowly rising triangular waveform, fed to the oscillator circuit (Fig. 2B), that causes a rising tone to be generated by *Q2* and *Q3*. However, when *Q1* (Fig. 2A) conducts and *C2* discharges, *D1* becomes reverse-biased (stops conducting), causing *C3* to discharge slowly through *R2* and *R3*. This action causes a falling tone, generated by *Q2* and *Q3*, which continues to fall until the rising voltage on *C2* is greater than the voltage on *C3* (actually about 0.7 volt greater to overcome the threshold of the silicon diode), when the cycle repeats. The rise time of the triangular waveform is controlled by *C2* and *R1* while the fall time is controlled by *C3* and *R2*.

Obviously, there is no need for a push-button when using the triangular-wave generator discussed above since the siren cycle will continue to provide a loud sound until power is interrupted.

The triangular-wave generator shown in Fig. 2A is for 12-volt, high-power operation, but can also be used with the lower power oscillator of Fig. 1A. As shown in the lead photo and the photo below, the entire panic-button circuit can easily fit into a small chassis box. ▲

Power siren with automatic cycling showing siren "On-Off" switch.

Power Transistors—a Status Report

(*Continued from page* 29)

(making a converter) produces a high d.c. voltage suitable for specialized vacuum tubes—cathode-ray tubes, high-power r.f. amplifiers, and indicator tubes.

Inverters are most conveniently operated at relatively high switching frequencies, where the transformers required can be kept small. Recently developed 50-ampere epitaxial silicon power transistors, the 2N5683, are ideal for this application. They feature very low saturation voltage (maximum 1 V at 25 A, typically only ⅓ V) for low losses at low supply voltages, and make possible 360-W (12 V, 30 A) inverters using only two transistors. These transistors use 275-mil square chips (that's over ¼ inch), which explains their high gain (15 min at 25 A) and excellent safe area. They are packaged in TO-3 type cases with extra large emitter pins. Both *p-n-p* and *n-p-n* varieties are available.

Electromechanical Drivers. Many power transistors are used as power switches to drive inductive components, such as relays, solenoids, printers, motor fields, transformers, and car ignition coils. This type of operation is demanding due to the high voltage generated by the inductor when the transistor turns off. Silicon transistors, with their high-voltage capabilities, are ideal here, but even so, a clamping diode is normally placed across the inductor.

Television Deflection. One of the most demanding applications of power transistors is as the horizontal-deflection output in a television receiver. A silicon transistor is necessary here in all but the smaller screen sets, where a germanium device is being used. The output transistor in a transformer-operated black-and-white set must handle 700 V in the "off" state and 3 A in the "on" state. It must also have current gain, good safe area, and short fall time. The horizontal-output stage in a direct-line-operated receiver must have a voltage rating of 1200 to 1400 V. Black-and-white sets require 1.5-A ratings, while color requires 3 A. In all cases, the transistors must be inexpensive to make them practical for use in receivers competing with older vacuum-tube sets.

Vertical deflection is less demanding, but still requires relatively high performance. A new annular power transistor, the MJ1800, has been developed specifically for this application. It's a 500-V transistor with excellent safe area and high gain linearity over the required current range.

We have described the current state of power transistors and hinted at their future. In germanium power transistors, even though the market is slowly weakening, advantages of these devices and future improvements should keep them around for many years.

In silicon, we can expect to see continual expansion of transistor voltage, current, and power ratings. One trend in the near future will be filling in the present gap between 60- to 80-V high-current types and high-voltage (300 V), low-current devices with new 100- to 140-V single-diffused transistors. These permit the use of relatively high supply voltages, simplifying filtering and heat-sinking requirements.

With the development of annular power transistors, more high-power monolithic devices and high-reliability parts should become available. We should also see more power transistor chips in hybrid circuits. Improved production processes, such as the use of 2- by 6-inch rectangular silicon slabs to increase the number of transistors manufactured simultaneously, rather than 1- or 2-inch circular wafers, along with increased use of plastic and aluminum packaging, should help reduce prices even as the devices improve. These developments should assure the continuing popularity of power transistors for the foreseeable future, with little competition expected from integrated circuits or other devices. ▲

Power Line as Standard

(Continued from page 47)

rounding is observed, adjust the "Sync Trigger Level" so that the sweep triggers nearer to the zero-volt crossover point so that the waveform appears as a straight line.

9. The desired time interval is equal to distance between the points where waveform crosses top and bottom graticules (or calibration marks).

10. If the time interval desired is a multiple of ½ the period of the 60-Hz sinewave (8.33 ms), you need not measure the voltage, you can count the number of half sinewaves and multiply by 8.33 milliseconds (Table 1). However, it is still important to set the "Sync Trigger Level" so that the sweep triggers as close as possible to the zero-volt crossover point.

11. If your scope has poor persistency, you may have trouble seeing the trace at very high sweep speeds, necessitating the use of a scope hood or turning the room lights down.

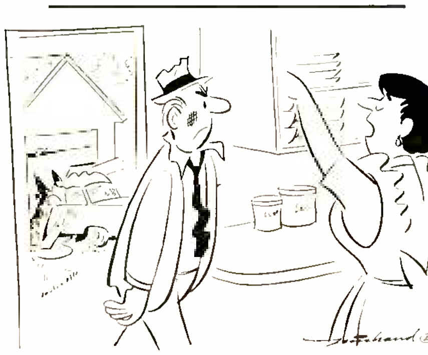
To calibrate the sweep time of your scope using the calibration circuit of Fig. 3, proceed as follows:

1. Using the procedure described in step 2, above, connect the high side of the 120-volt to the "A.C. (High)" input of the calibration circuit and the "A.C. (Low)" input to the other contact of the 120-volt a.c. line. *Use extreme caution to avoid electrical shock since the scope chassis may be at a higher voltage than water pipes or earth.*

2. Connect the scope vertical input to the output corresponding to the time interval you wish to measure.

3. Set the sweep in the middle of the scale and adjust the vertical gain so that the peak-to-peak amplitude is centered between the top and bottom graticules. (If there are no graticules, mark the peak-to-peak amplitude points.) The vertical gain is now calibrated for the desired time interval to be measured. Be careful not to move vertical gain control until you have completed test.

4. Repeat procedures described in steps 4-11. ▲



"The man couldn't fix the electric eye on the garage door, so he took it to the shop."

BOOKS

"ELEMENTARY TECHNICAL MATHEMATICS" by Frank L. Juszli & Charles A. Rodgers. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 597 pages. Price $9.95.

This is an excellent text for students taking technical courses offered by community colleges, technical institutes, and industry if their previous mathematical training has been confined to a year of high-school algebra.

Emphasis is on usable information in a non-rigorous format. The book covers the integrated algebra, geometry, and trigonometry required in technical programs. Special emphasis is placed on the use of the slide rule and an understanding of logs and exponentials.

The text includes almost 3000 exercises to check the student's grasp of the subject, 275 illustrations and graphs, and nearly 300 solved problems to demonstrate problem-solving techniques.

Although designed as a classroom text, there is no reason why this clear, well-written book couldn't be used by the student studying on his own.

* * *

"BASIC NUCLEAR ELECTRONICS" by Hai Hung Chiang. Published by *John Wiley & Sons, Inc.*, New York, N. Y. 337 pages. Price $14.95.

The proliferation of nuclear systems has created a need for understanding nuclear-electronic instrumentation. This book is designed to bridge the gap between theory and practice in nuclear instrumentation.

The text is divided into four chapters, each further subdivided into various sections. The first chapter deals with basic electronic devices and circuits, including networks, components, and basic network theorems. The second chapter deals with pulse amplifiers and single-channel analyzers while the third covers multichannel pulse-height analyzers. The final chapter discusses typical nuclear and electronic instruments and explains their operation and particular application.

Anyone capable of understanding the introductory chapter will have no trouble assimilating the balance of this authoritative and well-illustrated text.

* * *

"CBERS' HOW-TO BOOK" by Leo G. Sands. Published by *Hayden Book Company, Inc.* New York. 118 pages. Price $3.50 soft bound.

This latest volume from the "Old Pro" is designed for CB radio users, electronics experimenters, and technicians interested in doing CB servicing.

The "how-to" of the title is carried out in the five chapters dealing with CB equipment operation, buying CB equipment, installing it, testing and repairing CB gear, and modifying CB equipment.

* * *

"HANDBOOK OF ELECTRONIC PACKAGING" edited by Charles A Harper. Published by *McGraw-Hill Book Company*, New York. 948 pages. Price $29.50.

This massive volume represents the distilled knowledge of an impressive array of experts from some of the best-known electronic manufacturers in the country.

Emphasis has been placed on usability and the book is full of practical and useful data and guidelines on materials, components, processes, connection and interconnection techniques and devices, mechanical layouts, electrical factors, and thermal design with both microelectronic and conventional electronic packaging covered.

The text is divided into fifteen information-packed chapters covering design and application of rigid and flexible printed wiring, wires and cables, soldering and mechanical interconnections, welding and metal bonding techniques, depositions on microelectronics, connectors and interconnecting devices, materials for electronic packaging, packaging with conventional components and packaging of microelectronic and hybrid systems, electrical factors of electronic package design, thermal-design considerations, packaging for computer applications, military applications, and for space electronics, and computer-aided design. Since each of these chapters is prepared by the expert or experts in the field, the user will have the most authoritative and up-to-the-minute data at his beck and call.

* * *

"THE RADIO AMATEUR'S HANDBOOK" compiled and published by *The American Radio Relay League*, Newington, Conn. 610 pages plus tube and catalogue sections. Price $4.50 in U.S. Soft cover.

This is the 47th Edition of an old standby of the ham, student, and electronics engineer which has been extensively revised and updated in this 1970 edition.

New and additional material on state-of-the-art techniques and equipment has been included but without reducing the valuable information that both beginners and advanced hams have come to rely on. There are over 1300 illustrations including 576 tube-base diagrams (some of which seem to be available nowhere else).

All sorts of new construction projects have been incorporated, ranging from universal-type supplies to solid-state receivers, transmitters, and ham-station accessories.

It is hard to find any single volume that provides as much basic and down-to-earth data as this essential book.

* * *

"ELECTRONIC INSTRUMENTATION AND MEASUREMENT TECHNIQUES" by William David Cooper. Published by *Prentice-Hall, Inc.*, Englewood Cliffs, N.J. 483 pages. Price $12.95.

This is a good, basic handbook for technicians who are responsible for using and maintaining electronic test equipment for research, design, testing, and troubleshooting.

Although the format is that of a textbook with problems and questions at the end of each chapter, the practicing technician will find much of value in this book which can be immediately applied to his work-at-hand.

The first ten chapters of the volume cover the techniques and standard measuring instruments while the final five chapters are devoted to some of the more sophisticated equipment the technician is liable to encounter.

The author's clear and concise presentation is amplified by various types of illustrative material and, where required, the mathematics behind the operations. Those with a nodding acquaintance with algebra and a good working knowledge of arithmetic should have no trouble with this book as a home study or self-improvement text.

* * *

"TRANSMISSION LINES AND ANTENNAS" by Stephen Roman. Published by *Holt, Rinehart and Winston, Inc.*, New York. 139 pages. Price $3.95. Soft cover.

If your grasp of differential and integral calculus and basic vector algebra is in good working order, you should have no trouble deriving a great deal of benefit from this concise and no-nonsense book.

In seven well-illustrated chapters the author covers wave propagation, transmission lines and waveguides, radiation from antennas, low- and medium-frequency antennas, antenna arrays, and metallic reflectors and horns.

Four appendices cover vector analysis, Maxwell's equations, constants, and symbols while a bibliography gives the student other sources for additional study. ▲

Predetermining Decimal Counter

(*Continued from page 36*)

Fig. 4B is an output and recycle circuit. It takes the positive-going Carry output and converts it to a single high-power pulse of controlled duration, usable either as an output pulse or to reset the counters to 999. An inversion gives us a new Start Command for recycling purposes, if needed.

Fig. 4C is a Set-Reset Start Command flip-flop that gives a signal that lasts for the count period. Fig. 4D is a bounce-less push-button or mechanical contact conditioner, needed to prevent noise from erratically triggering the counter. Fig. 4E is a count gate that may be used to route input counts to an output only during the counting time.

Building Counting Systems

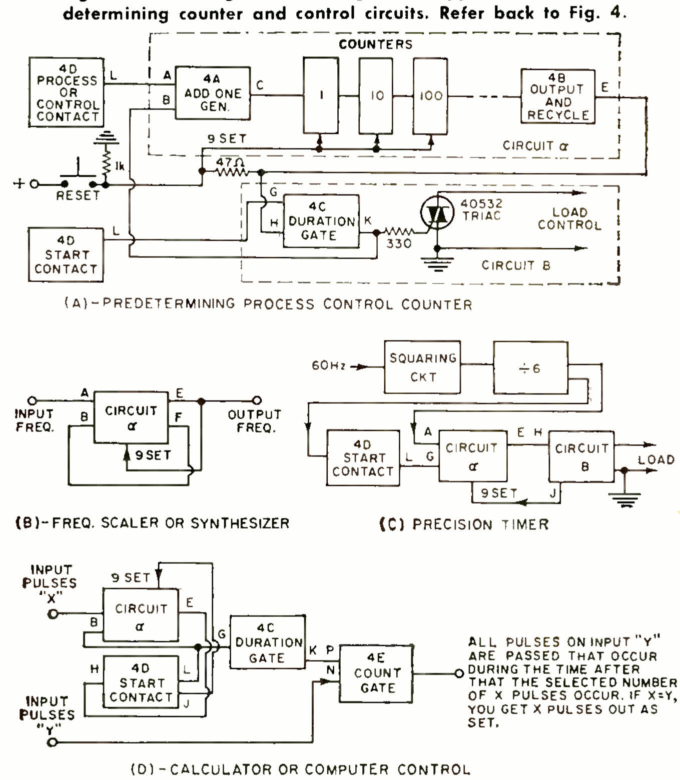
We'll rarely need all of the control blocks at once. Fig. 5 shows some uses for the control circuit blocks.

Fig. 5A is a predetermining process control counter. The first time around, a Reset button is pressed, followed by a Start Command. An a.c.-power-control output is provided for the time it takes to set up the selected count. Reset is automatic on all succeeding counts.

Fig. 5B is a lab scaler or frequency synthesizer that provides one output count for *n* input counts, where *n* is what you set into the counter. Input and output frequencies or pulse rates will be related by 1:*n*. Use this for nuclear event counting and lab scaling, as a musician's pitch reference, for a precision audio oscillator or signal generator, or as a v.f.o. replacement.

Fig. 5C shows a precision photo timer that counts the power line for excellent long-term accuracy. Divide-by-six versions of this counter can also be built containing one less IC. Fig. 5D shows a calculator or computer control circuit that has several uses. For keyboard entry, it can generate *n* pulses as selected. As part of a rate calculator or computer, it can gate all pulses arriving at input "Y" for a length of time determined by *n* of the pulses arriving on input "X." By properly relating X and Y, squares and square roots, multiplication and division, sines and cosines, etc. are easily included with some simple "rate multiplier" circuitry. ▲

Fig. 5. Block diagrams showing some applications for predetermining counter and control circuits. Refer back to Fig. 4.



C.E.T. Test, Section #4

Ohm's Law

By DICK GLASS*

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

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

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

1. To replace a .1-μF, 100-V capacitor, you might substitute:

(a) two .2-μF, 50-V capacitors in series
(b) two .1-μF, 200-V capacitors in series
(c) two .05-μF, 50-V capacitors in parallel
(d) two .10-μF, 200-V capacitors in parallel

2. Power dissipated in a 100-ohm resistor with ½ amp flowing is:

(a) 2.5 watts *(b) 25 watts* *(c) 5 watts* *(d) 50 watts*

3. A parallel-resonant *LC* trap passes higher frequencies:

(a) through the inductance
(b) through the combined resistance
(c) through the capacitance
(d) does not pass higher frequencies

4. With 10 volts across a 2- and 4-ohm parallel-resistor combination, the 2-ohm resistor will dissipate:

(a) 1/3 of the total power
(b) 1/2 of the total power
(c) 2/3 of the total power
(d) 11.1 watts

5. In a series-resonant *LC* tank circuit:

(a) higher frequencies are blocked by the capacitor
(b) lower frequencies are blocked by the capacitor
(c) reactance to the resonant frequency is highest
(d) the higher the "Q," the less the reactance

6. When a 20-ohm resistor is shunted with a 10-ohm resistor, the 20-ohm resistor will dissipate:

(a) less power *(b) more power* *(c) exactly the same power*

7. Which of the following might be an inductive reactance amount?

(a) 4 henrys *(b) .5 ohm* *(c) 5 mhos* *(d) .5 millihenry*

8. What current would flow with 5 volts across a 50-ohm resistor?

(a) .01 amp *(b) .1 milliamp* *(c) 100 milliamps* *(d) 10 amps*

9. Four .015-μF capacitors in parallel would measure:

(a) .00375 μF *(b) .6 μF* *(c) .06 μF* *(d) .0375 μF*

10. To replace a 120k-ohm, 2-watt resistor, you might correctly use the following series-resistor combinations as substitute:

(a) 100k, 1W and 20k, 1W
(b) 68k, 1W and 56k, 1/2W
(c) 110k, 2W and 10k, 1/2W
(d) 82k, 1W and 39k, 1W

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

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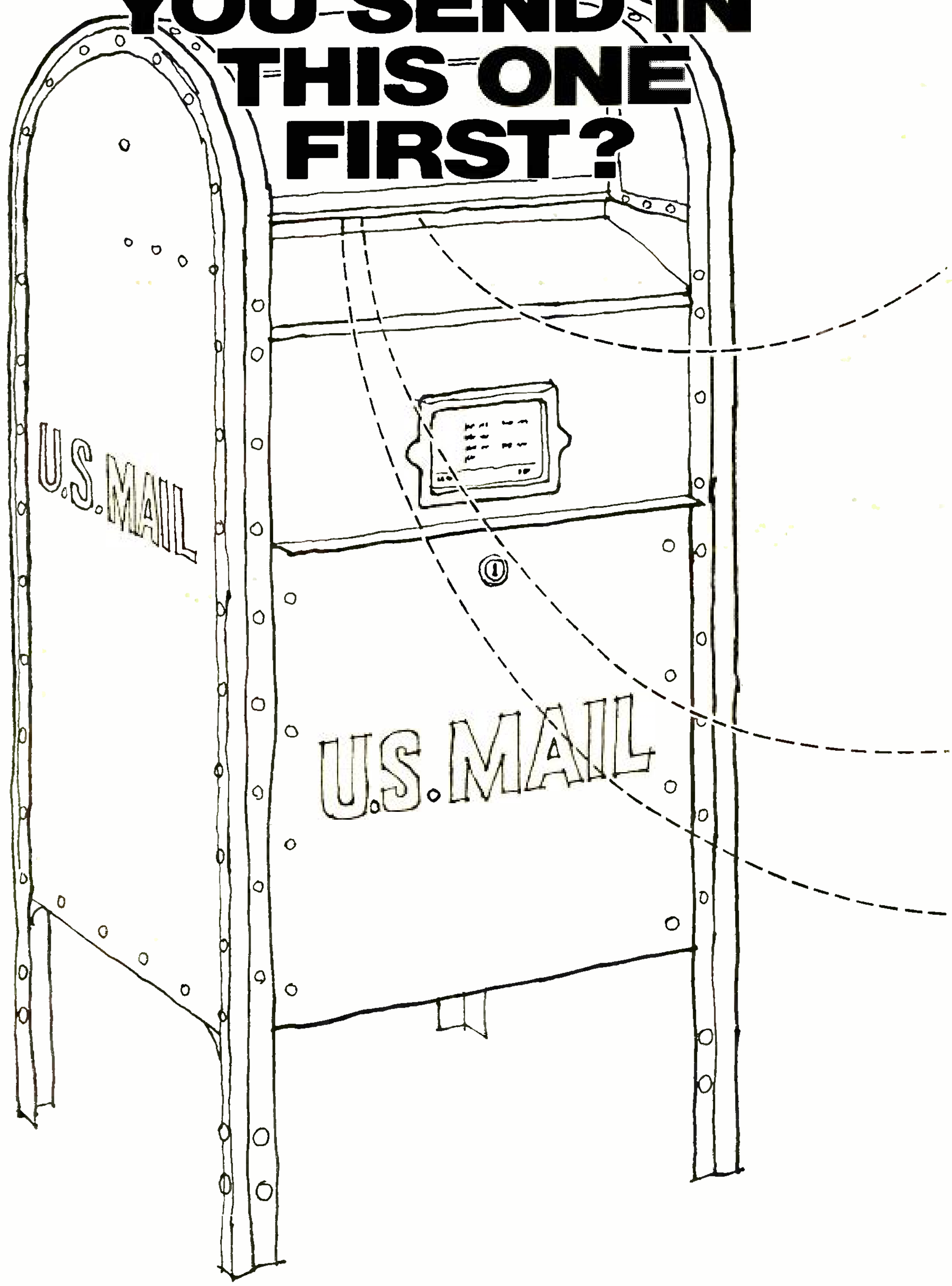

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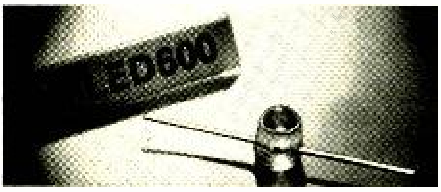
COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • COMMUNICATIONS

LIGHT-EMITTING DIODE

Motorola Semiconductor Products Inc. has expanded its line of optoelectronic semiconductors with the introduction of its first light-emitting diode, Type MLED600. Emitting in the visible red wave band with typical peak emission at 660



nm, the gallium arsenide-phosphide photodiode exhibits a minimum brightness of 50 footlamberts at 10 mA and typical brightness as high as 700 footlamberts at drive currents above 40 mA.

The high brightness makes the MLED600 suitable for use in applications such as punched-card readers, panel and circuit-condition indicators, shaft- and position encoders, credit-card and card-key verifiers, security systems, telephone dials, and bomb fuses. The short response time allows its use in light modulators, optical switching, and film marking and annotation.

Additional details on these plastic-packaged diodes will be supplied upon letterhead request to the Technical Information Center, Box 20924, Phoenix, Arizona 85036.

HAM-BAND RECEIVER

A moderately priced 80-10 meter ham-band receiver has been introduced as the Model A-2516. The receiver features a deluxe mechanical filter to provide highly selective AM, CW, and

SSB reception on all bands between 3.5 and 29.7 MHz. It will also receive the WWV frequency standard signal on 10 MHz.

This dual-conversion receiver features a crystal-controlled first local oscillator and a solid-state v.f.o.-type second oscillator having negligible frequency drift. The v.f.o. circuit has convenient output terminals for use as a transmitter v.f.o.

The receiver is housed in an olive-gray metal case which measures 7" x 13" x 10". A matching 5" speaker is available as an optional extra. Allied Radio.

Circle No. 6 on Reader Service Card

FUSE HOLDERS FOR PC BOARDS

A new subminiature fuse holder to accommodate either the Microfuse or subminiature Picofuse and intended for plug-in PC board applications has been developed by Littelfuse, Inc., 800 E. Northwest Highway, Des Plaines, Illinois 60016.

According to the company, one of the advantages of this new holder is the cost savings over the popular 3AG miniature fuse holder and fuse combination. The plug-in type holder measures 1/4" in diameter by 0.236" high with two 0.190" long x 0.019" phosphor bronze, silver-plated contacts. The holder is of molded acetal resin and is rated to 10 amps maximum at 125 volts a.c.

The Marketing Department of the company will supply additional details on request.

24-POSITION ROTARY SWITCH

Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Illinois 60525 has developed a miniaturized 24-position rotary switch with a diameter of 1.350" and a behind-panel dimension of 0.916" for a one-deck switch. Each additional deck adds approximately 0.333". The switch is available with one to twelve poles per deck and with as many as twelve decks in a switch. A total of twelve poles is the maximum per switch.

The totally enclosed explosion-proof design features molded-in base terminals, reducing contamination from the installation and operating environment. The switch also features the firm's detenting system which provides accurate and positive positioning.

This Series 53M15 switch is conservatively rated at 1/4 A, 117 V a.c. resistive load and 1/4 A, 6-28 V d.c. resistive load.

Ed Langille of the company will supply additional details on request.

FOUR-SPEED RECORD CHANGER

The Model 8401 four-speed automatic record changer is fully compatible with the company's AM/stereo-FM receiver systems and tape/radio systems.

The changer features a diamond/sapphire flip-style ceramic stereo cartridge, automatic or manual record play at 16, 33, 45, or 78 r/min, and a low-mass tubular aluminum tonearm. Stacks of up to six 7-in, 10-in, or 12-in records can be accommodated and the player comes with two 3-foot audio cables with phone plugs. A 45 r/min adapter and plastic dust cover are included. Craig

Circle No. 7 on Reader Service Card

V.H.F. MARINE RADIOPHONE

The Model 610 v.h.f. marine radiotelephone features a unique dual front-end receiver design giving full sensitivity on both simplex and duplex channels, and providing optimum selectivity and intermodulation rejection for loud and clear reception at sea and in big city harbors, according to the manufacturer.

Designed for operation in the uncrowded v.h.f. portion of the marine radio band, this solid-state,

25-watt radiotelephone provides dependable ship-to-ship communications up to 30 miles, and ship-to-shore communications up to 50 miles.

The Model 610 comes with mounting tray, microphone, crystals for operation on 156.8 and 156.3 MHz, and a fiberglass marine antenna with chrome laydown mounting base. Communications Company

Circle No. 8 on Reader Service Card

POLYCARBONATE CAPACITORS

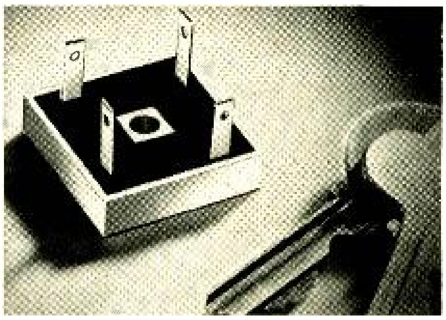
Wesco Electrical Co., Inc., 27 Oliver Street, Greenfield, Mass. 01301 has announced that its Type 32MPC capacitors are now available in voltage ratings from 50 to 200 V d.c. According to the company, this new line offers one of the smallest 50-volt film capacitors available; a 10-μF unit occupying less than 0.3 cubic inch and measuring 0.5" x 1.87" long.

The units are encased in a space-saving thermosetting polyester tape wrap, with epoxy and seals, to meet the environmental requirements of MIL-C-27287. Temperature range is $-55°$ C to $+85°$ C and may be operated to $+125°$ C with 50% derating.

Capacitance range is 0.012 through 10 μF with standard tolerance $\pm10\%$ and $\pm1\%$ tolerance available if required.

SILICON BRIDGE RECTIFIER

A new series of miniature, single-phase silicon bridge rectifiers for PC applications is now available. These Model XP409 bridges are encased in an aluminum housing that measures only 1-inch



square by 1/4-inch high, yet are rated for 15-A resistive-inductive loads. Mounting requires a single #6 screw.

At 60 Hz, electrical characteristics include 8 peak inverse voltage ratings from 100 to 800 volts with maximum inputs from 70 to 560 volts r.m.s., approximate thermo-resistance of 4° C per watt, and a maximum surge current rating of 240 amperes. Power dissipation is 33 watts. Sarkes Tarzian

Circle No. 9 on Reader Service Card

ONE-GUN BOOSTER

A solid-state, one-gun booster for color-TV picture tubes extends color-gun life by restoring the brilliance of either the red, blue, or green gun. Unlike regular brighteners that boost all three colors equally, this unit will boost the one weak color needed for a balanced color picture.

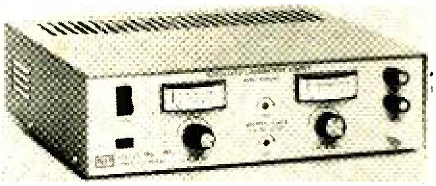
Installation is easy with self-stripping connectors that are included in the package. Workman

Circle No. 10 on Reader Service Card

REGULATED POWER SUPPLY

A regulated system power supply with adjustable power "turn-on/turn off" delays has recently been introduced as the Model V3215LO3. The delays prevent damage to components since critical voltages may be applied or removed in correct sequence.

The unit features state-of-the-art solid-state components, has continuously adjustable current



limiting, and adjustable output voltages with coarse and fine controls. Input is 105-125 volts a.c., 57 to 420 Hz. Output is floating 0-32 volts d.c. at 0-1.5 A. Ripple is less than 600 μV r.m.s. at 60 Hz.

The unit, which weighs under 10 pounds, measures 10" wide x 2¾" high x 8⅝" deep. Complete specs are available. Nottil Industries

Circle No. 11 on Reader Service Card

INTEGRATED STEREO AMP

The TA-1144 preamp/amplifier features all silicon transistors to provide 70 watts dynamic

power (IHF) into an 8-ohm load without distortion, according to the company. A quasi-complementary symmetry circuit provides low distortion and high damping factor at low frequencies.

The unit has two pairs of phono input connectors for two turntable systems, a binaural auxiliary input connector for duplicating tape or temporary use, a pre/power amplifier selector for a multichannel system, and easy-to-read tone and balance controls.

Amplifier frequency response is 15-300,000 Hz +0, −2 dB; harmonic and IM distortion is less than 0.2% at rated output and 0.05% at 1 watt. Sony Corp.

Circle No. 12 on Reader Service Card

INDUSTRIAL-GRADE SCOPES

For checking out the performance of digital process controllers, CCTV systems, medium-speed computers, and ultrasonic systems, two new industrial oscilloscopes with a frequency response from d.c. to 7 MHz have been introduced.

These new scopes, Models 1215A and 1217A, are additions to the company's 1200-Series scopes and are identical to earlier models with respect to all-solid-state construction, versatile time-base performance, and rock-solid stability, except that their frequency range is much broader.

The Model 1215A is a single-channel instrument while the Model 1217A is a dual-channel unit for displaying two waveforms. Both instruments have deflection factors ranging from 5 mV/div. to 20 V/div. with 21 sweep times ranging from 1 μs/div. to 5 s/div. with stable triggering on any signal that causes ½ division or more deflection or, for external triggers, that has an amplitude of 0.2 V or more.

Complete specifications on either or both of these scopes will be forwarded on request. Hewlett-Packard

Circle No. 13 on Reader Service Card

MONO CASSETTE RECORDER

A new portable mono cassette recorder with random function controls and door loading has been introduced as the Micro 9.

The design features posi-touch controls that allow random switching from one function, such as fast-forward, to another, such as rewind, without using the stop control. The door-loading feature allows rapid, easy insertion and removal of cassettes.

The 5½-pound recorder operates on a built-in battery supply or regular house current and can be used on a 12-volt source with an optional adapter. It comes with remote-control dynamic mike, earphone, a.c. line cord, leatherette carrying case, and a C-30 blank cartridge. Ampex

Circle No. 14 on Reader Service Card

WIRELESS HEADSET

A completely self-contained wireless r.f. broadcast combination headphone/microphone has been introduced. It does not require FCC licensing since it operates at less than 100 mW. The

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Your subscription to ELECTRONICS WORLD is maintained on one of the world's most modern, efficient computer systems, and if you're like 99% of our subscribers, you'll never have any reason to complain about your subscription service.

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unit comes complete with r.f. transmitter, receiver, and power supply. The electronics are compactly housed in a patented circumaural cup and includes an active boom-mounted microphone.

These units are suitable for use in a wide variety of educational, industrial, and broadcast communications applications. Sharpe

Circle No. 15 on Reader Service Card

HIGH-POWER STEREO RECEIVER

The 3800 AM/stereo-FM receiver features a "human-engineered" exterior including an upward-angled panel and dial and a computer-style keyboard. The tuning knob is weighted and balanced for better "feel" and faster tuning across

the dial. The pedestal-based walnut cabinet is integral to the total design and is included in the purchase price.

The receiver is rated 210 watts at 4 ohms ±1 dB, 85 W/channel (IHF dynamic) at 4 ohms, and 53 W/channel at 4 ohms and 43 W/channel at 8 ohms continuous power. Selectivity is 42 dB and frequency response is 15-30,000 Hz ±1 dB. H. H. Scott

Circle No. 16 on Reader Service Card

MARINE RADIOTELEPHONE

The "Model T" v.h.f. marine radiotelephone features frequency coverage from 156.25 to 158 MHz, power output of 6 watts into 50 ohms (reduceable to 1 watt with front-panel switch), and four push-button-controlled channels. Audio response is +1 dB to −3 dB from 300 to 3000 Hz.

The receiver is a crystal-controlled, dual-conversion superhet with a frequency range of 156.2-157.5 MHz and 161.0-162.55 MHz. Frequency stability is 0.001% from −30° C to +60° C. It features fully regulated and compensated squelch, intermodulation interference rejection of −70 dB min. to 76 dB typical, and an audio output of 2 watts with less than 10% distortion. Power requirements are 12 volts d.c. ground (polarity protected).

A data sheet with full specs will be forwarded on request. Simpson Electronics

Circle No. 17 on Reader Service Card

SUBMINIATURE LAMP

The #253 lamp which projects a critically focussed lens-end beam is now available in production quantities from Lamps, Incorporated, 17000 South Western Ave., Gardena, California 90247.

According to the company, the new #253 eliminates problems traditionally associated with lens-end light sources in critical applications. The new design uses a straight-sided glass envelope (T-1¼ from lens-end to base) aligned in a T-1¾ base to assure perfect fit. The new unit is interchangeable with industry standards #253 and #253X.

The new lamp can be used with card readers, encoders, and similar light-sensing devices where focus and intensity are critical. It is rated at 2½ volts. Average life is 10,000 hours.

POWER TRANSISTOR KIT

Solitron Devices, Inc., Semiconductor Division, 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404 has developed a new 13.5-V r.f. power transistor kit for commercial mobile radio applications.

This three-device kit, the SRK2028, will deliver 25 watts of output power at frequencies up to 175 MHz. The output stage is capable of withstanding infinite v.s.w.r. The kit consists of a pre-driver (SRF23211), driver (SRF13213), and output stage (SRF54215R) packaged in a strip-line stud case.

HIGH-DENSITY RECORDING TAPES

Two new high-density audio recording tapes are now being marketed in both cassette and open-reel formats. The open reels come in all the standard lengths and can be recorded and played on all tape recorders.

The two tapes, UHD (ultra high density) and HD (high density), feature an exclusive gamma "ferric oxide particle" orientation process which the company claims produces appreciably higher fidelity recording, irrespective of factory bias setting, at all speeds. Bell & Howell

Circle No. 18 on Reader Service Card

STEREO RECEIVER

The KR-7070 stereo receiver incorporates a powerful amplifier section as well as an AM FM tuner which features both automatic and remote-control tuning for easy, and for accurate station selection.

The new tuning system operates for AM, FM, or stereo FM, scanning the dial either to the left or right and picking up each station in sequence. One unique feature is the auto-tuning circuit that selects only stereo-FM stations, bypassing all others.

The circuit incorporates four IC's and crystal

filter for FM i.f. stages, a 3-FET, 4-gang tuning capacitor FM front-end, and an FET mechanical filter in the AM tuner section.

Power bandwidth (IHF) is 10-30,000 Hz and main input frequency response is 5-120,000 Hz (±1.5 dB).

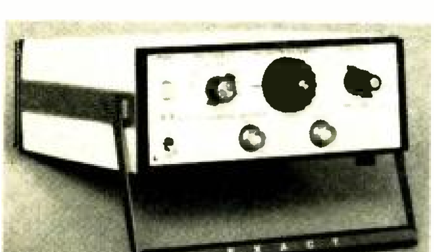
Complete specifications on the KR-7070 are available on request. Kenwood

Circle No. 19 on Reader Service Card

WAVEFORM GENERATOR

The new Model 120 waveform generator features a floating output provision, Kelvin-Varley divider frequency control, a 0.1 Hz to 3 MHz frequency range, a search mode for manually sweeping over two decades, a convenient handle / tilt stand, and miniature size.

The unit provides a precision source of sine, square, and triangular waveforms with a fre-



quency stability of 0.04% of setting for 10 minutes and 0.2% of setting for 24 hours.

Input voltage is 115/220 V a.c. at a frequency of 50 to 400 Hz. The unit measures 7⅜" wide x 2⅞" high x 8½" deep. It weighs just 4 pounds.

The company will forward a spec sheet on the Model 120 on request. Exact Electronics

Circle No. 20 on Reader Service Card

MAGNETIC TAPE TRANSPORT

Magnetic Recording Systems, Inc., 496 Grand Boulevard, Westbury, N.Y. 11590 has developed an OEM magnetic tape drive for specialized audio, instrumentation, and communications applications. The drive system is capable of precise, variable speed from standstill to 120 in/s (as well as in discrete steps) with rapid start-stop characteristics.

The unit has independent reel servos and constant tape tension in all modes. It features a direct-drive capstan servo that can be controlled from its own internal oscillator or from an external source. A rewind speed of 500 inches-per-second gives the system excellent search capability, and with the constant-tension tape path, good tape packing is assured, according to the manufacturer of the transport.

The transport can accommodate up to 10½" NAB reels. It uses IC's throughout (except for the servo power stages) and operates from 117 V a.c. or ±12-V battery-powered d.c.

HEAVY-DUTY CASSETTE RECORDER

A rugged, heavy-duty, a.c.-powered cassette recorder with a built-in slide/filmstrip synchronizer has been introduced as the Model 2550. The basic mechanism of this audio-visual recorder consists of a full-sized heavy flywheel, a large-diameter sturdy capstan, and a long-life a.c. motor. The slide synchronization unit uses a 60-Hz signal to activate the tripping mechanism. The use of 60 Hz minimizes cross-talk between the narration and the sync signal tracks.

All operating controls are conveniently located, color-coded for fast, intuitive action, and safety interlocked to prevent accidental erasure of tape. An automatic record level control assures high-quality recordings without need for manual monitoring, according to the company. 3M/Wollensak

Circle No. 21 on Reader Service Card

MANUFACTURERS' LITERATURE

POWER SUPPLIES

A condensed, 28-page catalogue entitled "Power Supplies Unlimited," has just been issued by NJE Corporation.

It features the LVC II/PVC line of laboratory and bench supplies and describes system rack and modular supplies, over 200 voltage and current regulation models, high-voltage supplies from 2.5 to 250 kV, frequency converters 60 Hz to 400 Hz, and a complete description of the firm's custom capabilities.

For copies of this useful publication, address your request to J. Robert Hoeffler of the company at 20 Boright Ave., Kenilworth, N.J. 07033.

POWER TRANSISTOR MANUAL

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404 has issued a new "Radiation Hardened Silicon Power Transistor Manual" which is now available for distribution.

The manual contains engineering data sheets on the firm's BR100, BR101, and BR200, 201 device series, as well as a third and higher current series, the BR300, 301. Information on design parameters and processing techniques is also provided.

A special section is devoted to analysis of post-radiation data, with emphasis on h_{FE} and collector saturation voltage parameters.

Priced at $3.95 per copy, the manual may be ordered direct from the factory.

POTENTIOMETER CATALOGUE

Complete information on the new Series 450/45 potentiometers is available in catalogue 1001 just issued.

This 20-page publication provides electrical and mechanical specifications on commercial composition variable resistors $1\frac{5}{16}$" in diameter, with power ratings from ¼ to ¾ watt.

For a copy of this new catalogue, send your requests to the attention of R. L. Wilson, Sales Manager, CTS of Elkhart Div., 1142 West Beardsley Ave., Elkhart, Ind. 46514.

STANDARD POWER SUPPLIES

A complete line of standard power supply systems is described and illustrated in a new catalogue now available from Lambda Electronics Corp., 515 Broad Hollow Road, Melville, N.Y. 11746.

Described are four standard rack sizes which accommodate up to 16 single or dual output power supplies. Each system is supplied with standard power controls, systems metering panel, and cables so that the customer can order a complete power system ready to hook up to his systems. Because standard supplies and accessories are used, customers may select from over 350 power-supply models in stock.

METAL ENCLOSURES

Premier Metal Products Co., 337 Manida Street, Bronx, N.Y. 10474 now has available a new 56-page catalogue (No. 70) featuring a complete line of standard metal enclosures for the electronics industry.

The catalogue features complete modular systems, as well as smaller cabinets, panels, cases, chassis, accessories, and hardware in a wide range of sizes for flexibility and adaptability in designing package systems.

An entire section of the catalogue is devoted to detailed mechanical drawings of the enclosures.

PROBLEM-SOLVING TOOLS

The new, 40-page tool catalogue (SD-170) has been designed for both professional and amateur.

It gives complete listings and applications data on screwdrivers, nut drivers, pliers, wrenches, fasteners, and special-purpose tools. Vaco

Circle No. 22 on Reader Service Card

ELECTRONIC TUBE DIRECTORY

A 40-page, two-color catalogue which lists thousands of electronic tubes from such companies as Amperex, Bomac, Eimac, GE, Genalex, ITT, Machlett, National, Raytheon, Westinghouse, Varian, and Sylvania is available. Listings are by numerical designations and, in some cases, suitable substitutes have been suggested when original tube numbers are no longer available. Metropolitan Supply

Circle No. 23 on Reader Service Card

TEST INSTRUMENTS

A new 12-page, 1970 catalogue describing the company's complete line of advanced electronic test equipment for servicing and industry has been issued as Form No. 517.

The catalogue includes details on five completely new instruments, including a tube tester, two color generators, an FET transistor tester, and a 7-in-1 bias supply. Other instruments covered in the catalogue are field-effect meters, sweep and marker generator, sweep circuit analyzer, combination scope/vectorscope, combination transistor/FET testers, CRT tester, and special-purpose instruments. Sencore

Circle No. 24 on Reader Service Card

ELECTRONICS TEACHING KITS

A 36-page catalogue which lists an extensive line of electronic projects designed for schools is now available for distribution.

This lavishly illustrated, full-color publication lists 18 projects ranging in complexity from resistance and capacitance boxes to printed-circuit transmitters and all-band radio receivers. An extensive line of components and project accessories is also listed. Graymark

Circle No. 25 on Reader Service Card

HI-FI ENSEMBLES

A four-color brochure which pictures and de-

(*Continued on page 82*)


Join "THE TROUBLESHOOTERS"
They get paid top salaries for keeping today's electronic world running
Suddenly the whole world is going electronic! And behind the microwave towers, push-button phones, computers, mobile radio, television equipment, guided missiles, etc., stand THE TROUBLESHOOTERS—the men needed to inspect, install, and service these modern miracles. They enjoy their work, and get well paid for it. Here's how you can join their privileged ranks—without having to quit your job or go to college in order to get the necessary training.

JUST THINK how much in demand you would be if you could prevent a TV station from going off the air by repairing a transmitter...keep a whole assembly line moving by fixing automated production controls...prevent a bank, an airline, or your government from making serious mistakes by servicing a computer.

Today, whole industries depend on Electronics. When breakdowns or emergencies occur, someone has got to move in, take over, and keep things running. That calls for one of a new breed of technicians—The Troubleshooters.

Because they prevent expensive mistakes or delays, they get top pay—and a title to match. At Xerox and Philco, they're called Technical Representatives. At IBM they're Customer Engineers. In radio or TV, they're the Broadcast Engineers.

What do you need to break into the ranks of The Troubleshooters? You might think you need a college degree, but you don't. What you need is know-how—the kind a good TV service technician has—only lots more.

Think With Your Head, Not Your Hands

As one of The Troubleshooters, you'll have to be ready to tackle a wide variety of electronic problems. You may not be able to dismantle what you're working on—you must be able to take it apart "in your head." You'll have to know enough Electronics to understand the engineering specs, read the wiring diagrams, and calculate how the circuits should test at any given point.

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For over 30 years, the Cleveland Institute of Electronics has specialized in teaching Electronics at home. We've developed special techniques that make learning easy, even if you've had trouble studying before. Our AUTO-PROGRAMMED® lessons build your knowledge as easily and solidly as you'd build a brick wall—one brick at a time. And our instruction is personal. Your teacher not only grades your work, he analyzes it to make sure you are thinking correctly. And he returns it the same day received, while everything is fresh in your mind.

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To keep up with the latest developments, our courses are constantly being revised. This year CIE students are getting new lessons in Laser Theory and Application, Microminiaturization, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra.

In addition, there is complete material on the latest troubleshooting techniques including Tandem System, Localizing through Bracketing, Equal Likelihood and Half-Split Division, and In-circuit Transistor Checking. There are special lessons on servicing two-way mobile radio equipment, a lucrative field in which many of our students have set up their own businesses.

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And no wonder. The licensing exam is so tough that two out of three non-CIE men who take it fail. But our training is so effective that 9 out of 10 CIE graduates pass. That's why we can offer this famous warranty with confidence: If you complete a license preparation course, you get your FCC License—or your money back.

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

CIRCLE NO. 146 ON READER SERVICE CARD

scribes the company's handcrafted hi-fi ensembles is available. Details are provided on the Flamenco II, Valencia III, and Milano equipment and speaker cabinets. Altec Lansing

Circle No. 26 on Reader Service Card

STOCK RELAYS

A 36-page catalogue which lists hundreds of different in-stock types of microminiature, subminiature, telephone, aircraft, mercury wetted, differential, polar, sensitive, impulse, latching, vacuum, high-voltage, timing, sealed, resonant, stepping, and other relays is now available for distribution.

Most of the units pictured and described in Catalogue No. 170 are available in production quantities. Universal Relay

Circle No. 27 on Reader Service Card

PRESSURE-SENSITIVE TRANSISTORS

Specifications for "Pitran" pressure-sensitive transistors are detailed in six new data sheets now being offered.

Models with 1/10, ¼, ½, 1, 2, and 5 psid ranges are described and are available from stock. Stow Laboratories

Circle No. 28 on Reader Service Card

TV PARTS GUIDE

Copies of the 1970 Stancor "Color and Monochrome Television Parts Replacement Guide" are now available for distribution.

Listing over 500 transformer and deflection components, the new part-to-part cross-reference guide contains replacement parts for sets made by 200 TV manufacturers.

A new catalogue section has been added this year covering the Stancor line of flybacks, deflection yokes, vertical outputs, power and output transformers, and filter chokes, plus several pages of electrical schematics. Essex International

Circle No. 29 on Reader Service Card

WIREWOUNDS & RHEOSTATS

A 20-page catalogue covering an extensive line of wire-wound resistors and rheostats (ww/wl/270) is now available for distribution.

All of the items pictured and described in this booklet are stock items available from company distributors. Also included is a review of the company's dual-wattage rating system for wirewounds which the firm hopes will become an industry standard. Ward Leonard

Circle No. 30 on Reader Service Card

CONVERSION FACTORS

Centralab Electronics Division is now offering, free of charge, a 20-page booklet entitled "Conversion Factors and Formulae."

This reference booklet provides conversions of interest to electronics engineers that range from abcoulomb to webers as well as common formulas related to series and parallel circuits.

For a copy of this pocket-sized booklet, address your request to the attention of the Advertising Department of the company at 5757 N. Green Bay Ave., Milwaukee, Wis. 53201.

ZENER/VOLTAGE-REFERENCE DIODES

A cross-reference and selection guide for its extensive line of zener diodes and temperature-compensated reference diodes is now available from Distribution Services, Fairchild Semiconductor, Box 1058, Mountain View, Calif. 94040.

The guide, which folds into six 8½" x 11" pages, describes approximately 800 diode devices, including a series of 1-watt zeners. Each device listed in the folder is identified by its voltage, current, and impedance capabilities. Package information is also provided, together with diagram illustrations. ▲

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Answers to C.E.T. Test, Section #3

Published in Last Month's Issue:

1. **(a)** P1500 means that capacitance increases positively with temperature. 1500 indicates the number of parts per million of capacitance, per degree centigrade, that the capacitance changes with temperature.
2. **(c)** A gold fourth band indicates 5% tolerance in value from indicated size. Silver is 10%; no band is 20%.
3. **(c)** Interrupting an accelerated electron beam in a vacuum may cause x-radiation to be generated. Therefore, any surface may be a producer. The low-acceleration electron gun would be the least likely producer.
4. **(a)** Most conductors such as the copper wire in a yoke increase in resistance when hot. A thermistor decreases in resistance when hot; therefore, it compensates for the change in yoke resistance.
5. **(b)** The screen bypass is not critical and may be chosen to be 10 or more times larger than needed. The other choices are more critical.
6. **(c)** Lowering the impedance of the audio circuit reduces its ability to pick up extraneous voltages. Therefore, using a *low*-impedance microphone would tend to solve the problem. Any other answer results in high impedance which aggravates the problem.
7. **(b)** and **(d)** An integrator is a low-pass filter. High-frequency pulses would be bypassed, leaving the low-frequency pulses at the integrator output.
8. **(d)** Line transformers allow various choices of power selection to individual speakers without calculating impedance values, when used with constant-voltage amplifiers.
9. **(b)** The standard rule of thumb is: no lower voltage rating. 20% under to 100% over the rated capacitance.
10. **(a)** Silver mica capacitors have good thermal stability.

ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 85¢ per word (including name and address). Minimum order $8.50. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 50¢ per word (including name and address). No minimum! Payment must accompany copy.

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

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 4040 North Nashville Avenue, Chicago, Ill. 60634.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

METERS Surplus, new, used, panel or portable. Send for list. Hanchett, Box 5577, Riverside, Calif. 92507.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

INVESTIGATORS, LATEST ELECTRONIC AIDS. FREE LITERATURE. CLIFTON, 11500-J NW 7th AVE., MIAMI, FLORIDA 33168.

FREE ELECTRONICS PARTS FLYER. Large catalog $1.00 deposit. **BIGELOW ELECTRONICS, BLUFFTON, OHIO 45817.**

EUROPEAN wholesale new products catalog. $1.00 refundable. Deecow, 10639 Riverside, North Hollywood, Calif. 91602.

CIRCLE NO. 136 ON READER SERVICE CARD

TREASURE HUNTERS! Prospectors! Relco's new instruments detect buried gold, silver, coins. Kits, assembled models, Transistorized. Weighs 3 pounds. $19.95 up. Free catalog. Relco-A22, Box 10839, Houston Texas 77018.

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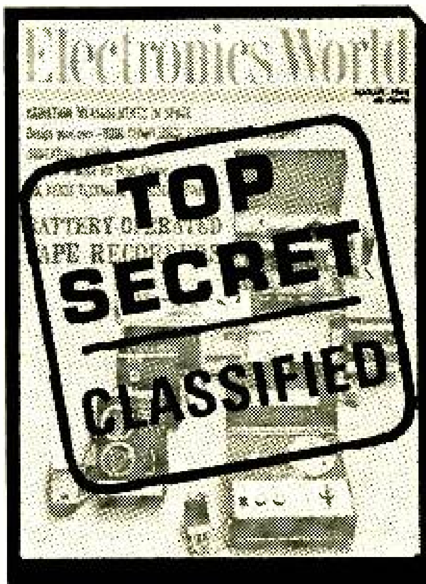

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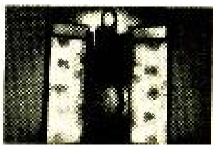

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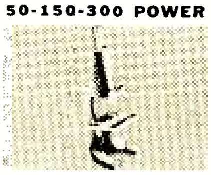

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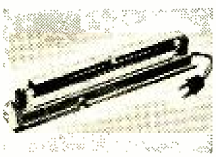

Extremely versatile, compactly designed, long wave (3200-4000 angstroms) black light (ultraviolet) fixture. Has 6-watt, 110-V lamp with built-in filter—eliminates harmful shorter wave ultraviolet rays. Use to identify minerals, fungi, bacteria—check for surface flaws, oil and gas leakage—perfect for displays with fluorescent paper, paints, chalk, crayons, trace powder. Incl. adjustable aluminum reflector, push-pull switch, connecting plug. Mount vert., horr., or on corner. 10" L., 1½" W., 1¼" H.

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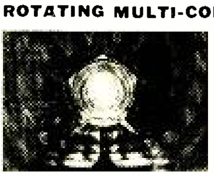

Dazzling colors stream endlessly from constantly rotating light. Facetted, transparent globe has louvered drum inside with red, green, blue & yellow stars. Bulb heat rotates drum which projects flickering star points on walls, ceilings, etc. while individual globe facets present constantly changing array of brilliant colors. 9¾" star—approx. 12" high on bell-shaped base. Surprisingly light. Easily placed on table, TV, fireplace, or Xmas tree top.

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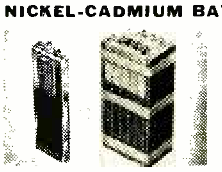

Terrific value—slightly used gov't surplus. Lightweight 5 cell, 6 volt, 4 Amp-hour battery with almost unlimited life. Extremely high current output. Recharges in 1 hour with Edmund kit. Won't deteriorate when left discharged. Minimum maintenance—few drops of water per year. Rugged, shock- and-vibration resistant nylon case. Delivered partially charged, filled with electrolyte 3⅛" x 2" x 6", 2 lb.

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100 information packed pages! Fully explains latest in psychedelic lighting equipment, techniques, developments. Covers all facets of psychedelic light-show production including strobes, black lights, projectors, crystals, organic slides, mirrros, color organs, polarized color light boxes, MusicVision, etc. Shows how to "psychedelize" parties, musical groups, shows or how to set up "electric trips" for private gatherings. 8½" x 11" looseleaf paper punched for 3 ring binder.

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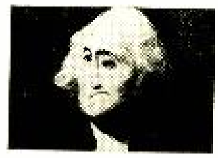

Now any amateur can produce all kinds of weird, wild, way-out photo effects. No special knowledge, or equipment required. Unique kit enables you to turn friends into monsters, show house with water to 2nd floor, make psychedelic slides, kaleidoscopic photos, impressionistic photo-art . . . unlimited possibilities. Complete instructions reveal the secrets . . . includes all accessories needed.

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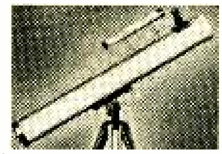

See moon shots, orbits—stars, phases of Venus, planets close up. 60 to 180 power. Aluminized and overcoated 3" diameter f/10 primary mirror, ventilated cell. Equatorial mount with locks on both axes. Equipped with 60x eyepiece and mounted Barlow lens. 3x finder telescope, hardwood tripod. Included FREE: "STAR CHART"; 272-page "HANDBOOK OF HEAVENS"; "HOW TO USE YOUR TELESCOPE."

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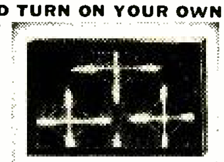

Psychedelic Light Show Take one bookshelf sized conservative looking oiled walnut finished light box—with its built-in kicker, an indiv. controlled 3-channel color organ. Activate by attaching to hi-fi or stereo speaker. Plug in and switch on! Music fills the room and the prismatic screen leaps into pulsating life. Patterns are wild and wonderful, or soft and soothing — responding directly in time and intensity to music. Perfect home entertainment, little theater or combos. House current.

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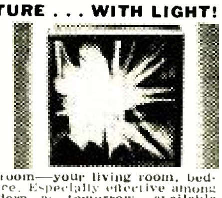

The almost hypnotic spell of ever changing firelight has been captured in a cool-light display box! With the liquid motions of a rising and cascading fountain blowing in the wind, psychedelic colors appear, intermingle and vanish to rise again in new patterns and drift away. This soothing light show housed in a handsome 11½" square by 7" deep, walnut finished lumia light box is an effective addition to any room—your living room, bedroom, rec-room, doctor's office. Especially effective among a wall picture group. Modern as tomorrow—available today!

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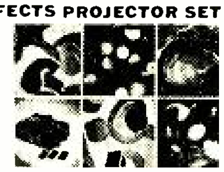

Dazzling, avante-garde visual effects. Fantastic variety. Incredibly beautiful. Special package offer contains all necessary apparatus. Create floating, exploding, fiery bursts of color like "Symphony of Spheres," "Chromatic Starbursts," "Crystal Starburst." Features 35mm 500 W. fan cooled projector—produces big image at short distance. Accepts two 9" diam. wheels (Dry Kaleidoscope & Hexidoscope), 2 cylindrical accessories (6" Colored Cloud & 5" Hexidoscope w/six internal mirrored walls). Perfect for entertaining, parties, photography. Complete instructions.

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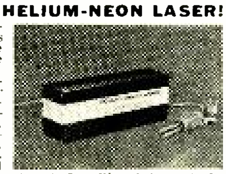

Completely assembled, instant-starting w/three times power output of comparable models. Steady, ripple-free light of moderate (safe) power. Excellent collimation. Particularly useful for studies, experiments in holography, interferometry, diffraction, optical alignment. Simple and safe to use—just plug in, switch on. The 4½ lb. unit reaches 75% power in 2 secs.; full power, typically 0.5 milliwatt (0.3 mW minimum) in 3 mins. Beam divergence only 2 milliradians (far ahead of competition); beam only 2 cms at 40 feet.

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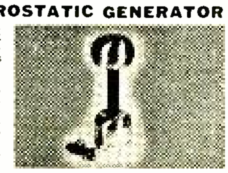

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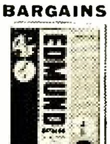

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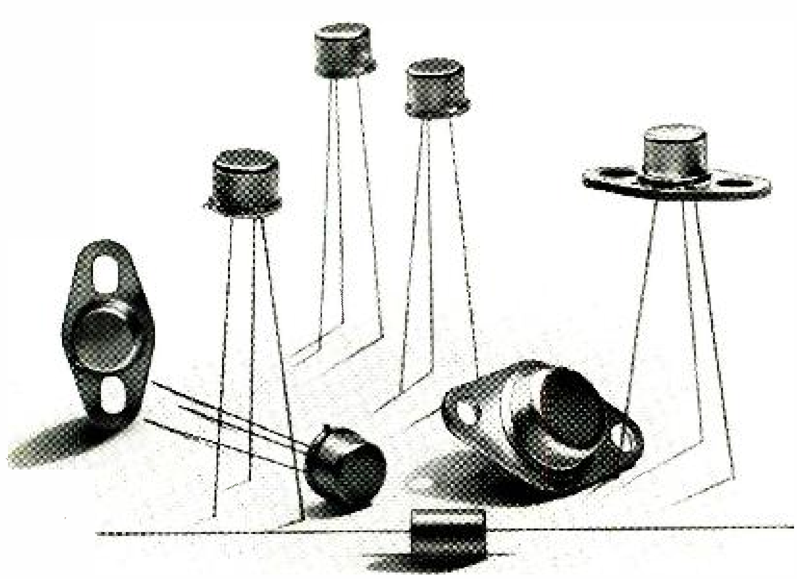

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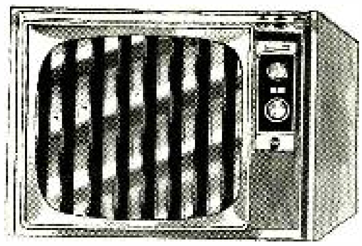

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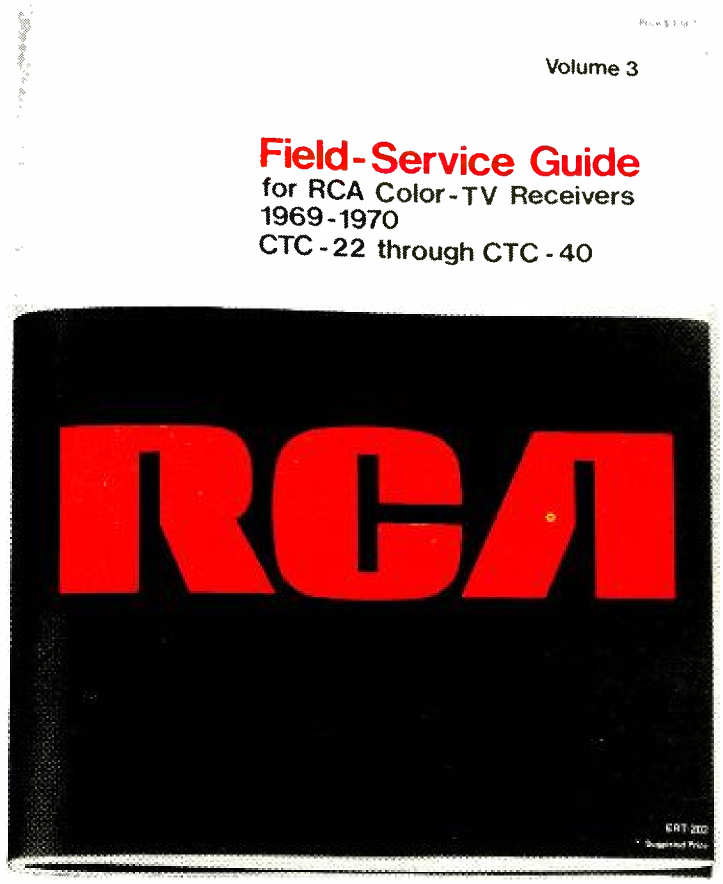

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