Electronics World

JUNE, 1971
60 CENTS

SOLDERING TOOLS • ELECTRONIC BARTENDER
NOISE FILTERS IN HI-FI AMPLIFIERS
THE TV PRODUCT-SERVICE TECHNICIAN—A Vocation Profile
HI-FI LAB REPORTS—Sansui 2000A Receiver & Rabco ST-4 Turntable/Arm

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NOW you can measure resistors accurately

IN CIRCUIT !

in solid state devices

FE20 HI-LO
with hi-voltage probe and large six-inch meter **$129.50**

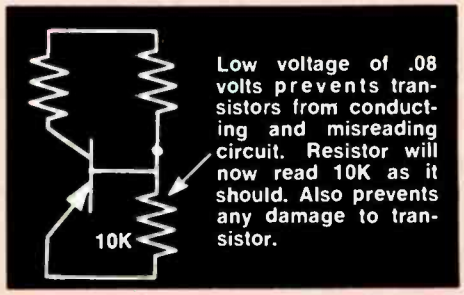
FE21 HI-LO with 4½-inch meter $99.50

WITH THE NEW HI-LO FIELD EFFECT MULTIMETERS

USES ONLY .08 VOLTS TO POWER OHMMETER TO PREVENT TRANSISTORS FROM CONDUCTING AND UPSETTING READINGS

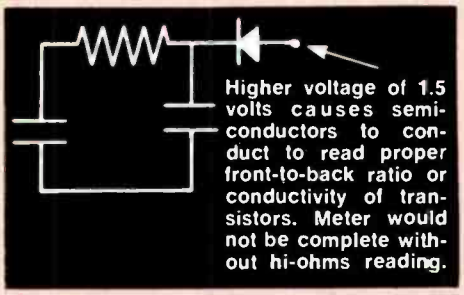
Look at these extra features to see why the Hi-Lo meter belongs on your want list:

- Unbelievable specifications of 15 megohm input impedance on DC and 12 megohms on AC
- Laboratory accuracy of 1.5 percent on DC and 3 percent on AC
- 9 DC voltage ranges from as low as .1 volts full scale to 1000 volts
- 3 hi-voltage ranges of 3 KV, 10 KV and 30 KV
- 9 DC zero center ranges from .05 volts to 500 volts . . . a must for delicate transistor bias measurements
- 7 resistance ranges from 1000 ohms full scale to 1000 megohms
- 9 DC current ranges from 100 microamps to 1 amp
- Automatic built-in battery test . . . never a worry about rundown batteries, just push the switches under the meter and read.
- Standard .6 amp fuse to protect the ohms and milliamps scales if voltage or overload is accidentally applied. No more need to return the meter to factory for repair . . . just replace the fuse.
- Special probe with 100K isolation resistor in probe to prevent AC pickup or to prevent loading oscillator circuits. Leave in normal position for most tests.



Low voltage of .08 volts prevents transistors from conducting and misreading circuit. Resistor will now read 10K as it should. Also prevents any damage to transistor.

Here is why you should have both Hi and Lo battery voltages for correct in-circuit resistance measurements in solid state circuits:

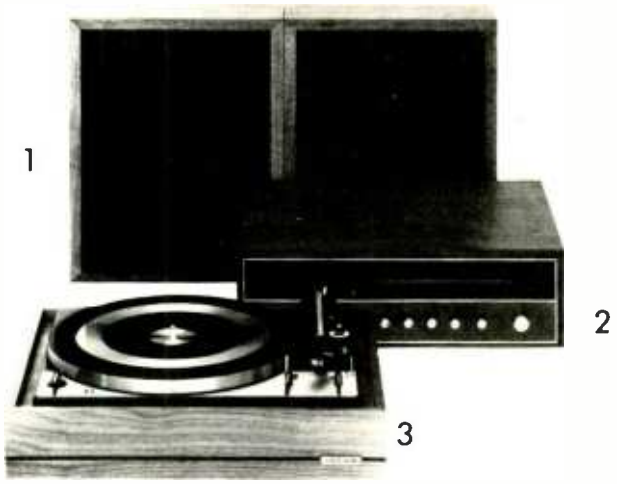


Higher voltage of 1.5 volts causes semiconductors to conduct to read proper front-to-back ratio or conductivity of transistors. Meter would not be complete without hi-ohms reading.

SENCORE INC. 3200 Sencore Drive • Sioux Falls, South Dakota 57107

CIRCLE NO. 123 ON READER SERVICE PAGE

What is the most expensive component in your stereo system?



Wrong.

Assuming that you picked one of the component types pictured here.

Although these three components form the typical stereo system, no system is actually complete without number four: records.

And no matter what you may have paid for your receiver, speakers, or turntable, chances are you've spent even more for your records. Or will before long.

Your records are not only your biggest investment, but the most vulnerable as well. They can remain as good as new for years or begin to wear the first time they're played. In which case they become even more expensive.

How to protect your investment.

Which brings us to the turntable, the one component that actually contacts your records and tracks their impressionable grooves with the unyielding hardness of a diamond.

What happens then is up to the tonearm. It must apply just the right amount of pressure to the stylus, keep this pressure equal on both walls of the groove, and follow the stylus without resistance as the groove spirals inward.

Then the stylus will be able to respond freely to all the twists and turns in the record groove, without digging in or chopping away.

How the Dual does it.

Dual tonearms are designed with great ingenuity and engineered to perfection. For example, the tonearm of the 1219 pivots exactly like a gyroscope: up and down within one ring, left and right within another. All four pivot points are identical, and nothing moves with the tonearm except the inner ring. If you can imagine 0.015 gram, that's the maximum resistance this tonearm offers to the stylus. This suspension system is called a gimbal, and no other automatic arm has it.

Another unique feature of the 1219 tonearm is the Mode Selector, which shifts the entire arm to set the correct stylus angle in either single or multiple play.

Also, the longer the tonearm, the lower the tracking error. Thus, the 1219's arm, 8¾" from pivot to stylus, is the longest of all automatic arms.

Other things to consider.

In addition to preserving records, a turntable must also bring out the best in them.

The record must rotate at precisely the right speed, or pitch will be off. The motor must be free of vibration, or rumble will be added to the music. The platter must weigh enough to provide effective flywheel action to smooth out speed fluctuations. And, of course, the stylus must get to and from the groove as gently as possible.

The professionals' choice.

All this is something to think about the next time you buy a record or play your favorite one. It's why Dual turntables have been the choice of professionals for so many years.

Not only for the way Duals get the most out of records (without taking anything away) but for their ruggedness, reliability and simplicity of operation.

If you'd like to know what independent labs say about Dual, we'll send you complete reprints of their reports. Plus an article on what to look for in record playing equipment, reprinted from a leading music magazine.

But if you're already convinced and can't wait, just visit your authorized United Audio dealer and ask for a demonstration.

You'll find Dual turntables priced from $99.50. It's not the least you can spend. But when you consider your investment in records, you may agree that it's the least you should spend.

United Audio Products, Inc., 120 So. Columbus Ave., Mt. Vernon, N.Y. 10553. Dual

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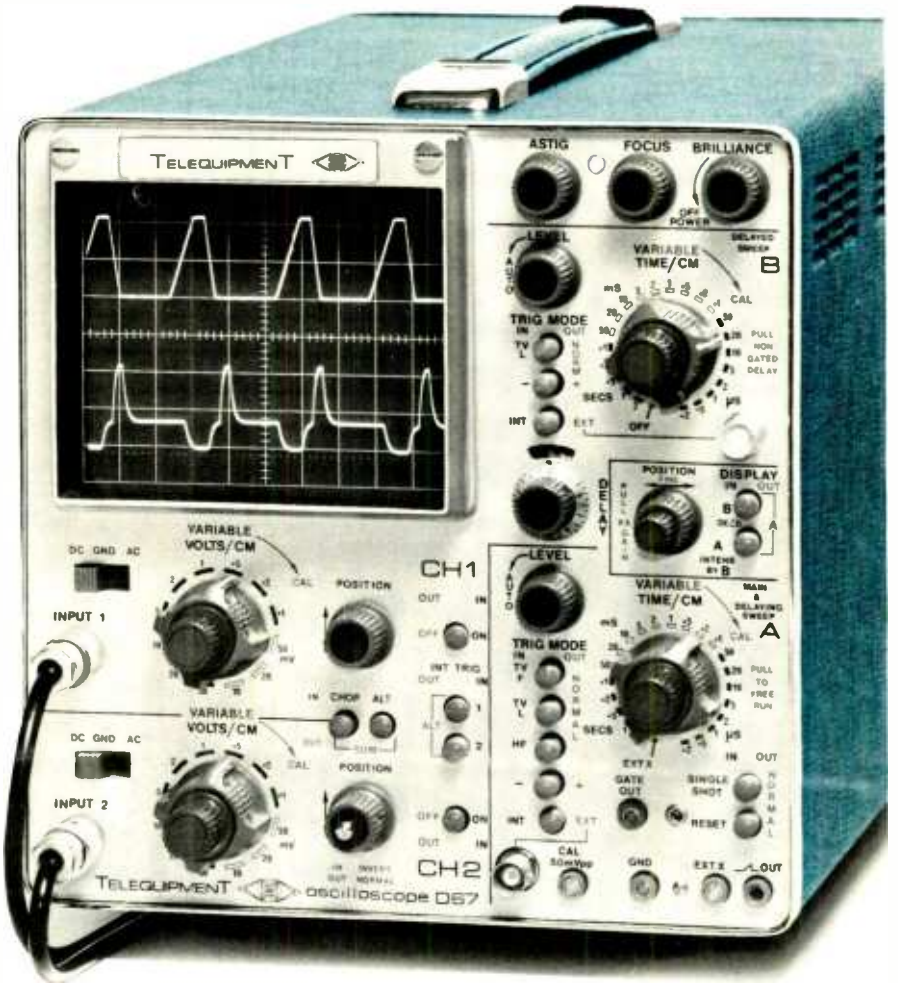

The new Telequipment D67 Oscilloscope offers the performance you have always desired at a price that is several hundred dollars lower than any other comparable model.

In addition to its impressive array of specifications, the D67 has other features not usually found in low-priced scopes: regulated power supplies, FET inputs to keep vertical trace drift to a minimum, fully solid-state design to improve reliability, transistors in sockets to make servicing easier and faster.

Bright displays are obtained by using 10-kV high voltage on the rectangular 5-inch CRT which has a big 8 x 10 cm display area.

A wide range of sweep rates from 2 s/cm to 0.2 μs/cm (40 ns with X5 magnifier), delayed sweep, 3% accuracy and 14-ns risetime, make the D67 ideal for high resolution analysis of pulse sequences. And if some of the pulses are jittery, that won't be a problem because the delayed sweep can be triggered. Those who have a need to view television signals will be pleased with the D67's ability to trigger at TV field and line rates. This feature allows viewing a selected line in a field.

Even if portability is not a prime consideration, you are certain to like the D67's lightweight—it weighs only 25 lbs.

Telequipment Oscilloscopes are marketed and supported in the U.S. through the Tektronix network of 57 Field Offices and 30 Service Centers. The instruments are warranted against defective parts and workmanship for one year. For more information call your nearby Tektronix field engineer or write: P. O. Box 500, Beaverton, Oregon 97005.

Telequipment Oscilloscope prices start as low as $245.

U.S. Sales Prices FOB Beaverton, Oregon

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CIRCLE NO. 143 ON READER SERVICE PAGE

Electronics World

JUNE 1971 VOL. 85, NO. 6

Contents

Coming Next Month

Special Feature Article

A LOOK AT TRANSISTOR TESTERS

An in-depth survey of what is available to the service technician for checking leakage currents, amplification, and displaying characteristic curves of transistors, FET's, and diodes. Testers, tracers, and probes are covered by Forest Belt in tabular form to facilitate "comparison shopping" for the right instrument for the kind of servicing you do.

Attachments to Your Telephone

A recent court decision that opened the way to the connection of "foreign" equipment to phone lines has resulted in a flood of such devices. What kind of devices can be used, what are telephone-company specs for such equipment, and how much does it cost? Read what Walter H. Buchsbaum has to say about this topic.

Measuring Color-TV Generated X-Rays

J. G. Ello of Argonne National Lab explains what kind of survey instruments are available, their comparative characteristics, and how they are used to check color sets to see that they conform to the provisions of the Radiation Control Act of January 1970.

The Optoelectronics Revolution

The conversion of electric current into light and light into electric current has given birth to a new technology known as optoelectronics. From discrete light emitters and detectors to complex arrays, these components are forerunners of a burgeoning technology which holds great promise as one of the new growth industries of the decade ahead. Learn all the details in this article.

All these and many more interesting and informative articles will be yours in the July issue of ELECTRONICS WORLD . . . . . on sale June 17th

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The Way to Get Ahead in Electronics is To Get More Knowledge Into Your Head And a Grantham Degree Into Your Pocket!

The above headline makes a point that affects more than your head and pocket. It can affect your *pocketbook* too. Getting ahead in the pocketbook is of great interest to most of us, and the Grantham ASEE Degree program not only helps you get a*head* in the pocketbook but also puts a better one on your shoulders. As an electronics technician, you can really get ahead by getting more eduction, and if you don't need a degree in your pocket why not hang it on the wall!

Maybe we don't write the best ads, but we really know how to teach electronics and related subjects by correspondence. We have been doing it for twenty years. AND we are the only home-study school in the United States ever accredited to award a *degree* in engineering. True, it's an associate rather than a baccalaureate degree, but that's because we teach only engineering and engineering-related subjects and do not include the humanities in our curriculum. Grantham awards the degree of *Associate in Science in Electronics Engineering*—a degree in college-level engineering rather than the usual junior-college kind of associate degree.

Advance beyond the technician level. Become an engineer. If you are a high school graduate and have a good aptitude for electronics and mathematics, you can earn the Degree of Associate in Science in Electronics Engineering mainly by

STUDYING AT HOME

Investigate *now* the Grantham college-level program in electronics engineering, offered (by correspondence) to working technicians while they remain on their jobs. Grantham lessons place heavy stress on fundamental concepts of logic and mathematics (taught so you can understand them), and build from there in a systematic manner, covering physics, circuits, and systems. The lessons are easy to understand because they are carefully written, with step-by-step explanations and consistent review and regrouping of ideas.

Now is the time, not only to protect yourself from unemployment, but also *to prepare yourself for the greater demand in engineering* which is sure to come. You can't become an engineer in a few short weeks; it takes many months. You can be upgrading yourself in your present job while the economy is "slow", and then *be ready to move into engineering* when the national economy gets going again. Yes, now is the time to prepare, so that *you* will be ready to take advantage of opportunity when it presents itself.

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NEWS HIGHLIGHTS

Bose Sues Consumers Union

The *Bose Corp.* has filed suit against *Consumers Union* for $500,000 in damages for what it says is a "biased and fraudulent" rating of its Model 901 loudspeaker system. *Bose* claims that the testing organization, whose report on the speaker appeared in the May, 1970 issue of "Consumer Reports," is biased against expensive products, uses faulty testing methods, injected misleading and sarcastic comments, and employed a tester holding a patent on a competitive speaker system. Although the *CU* report said that the speaker sound "seemed considerably more spacious and reverberant" than others it had tested, it went on to say that stereo localization was more difficult and there were "size distortions." The testing organization is standing behind its report and has dismissed the lawsuit as "a matter of pique." For our own report on the *Bose* Model 901 speaker system, see the November, 1968 issue.

Dumping is Ruled on Japanese TV Sets

The U.S. Tariff Commission has ruled that Japanese TV's should be subject to special dumping duties because they were being sold in this country at less than fair value and that domestic TV manufacturers were being injured by the imports. The U.S. imported 3.3 million TV sets valued at $255 million from Japan last year; these were largely portables and smaller-screen models. Domestic makers produced 7.8 million sets in 1970, probably valued at about $1.7 billion. The Electronic Industries Association (EIA) was gratified by the finding of the Tariff Commission. The EIA originally brought the case to the attention of the Treasury Dept. some three years ago. The immediate response of the Electronics Industries Association of Japan was that the decision was made under political duress. The Japanese trade association said further that "we intend to take any and all other steps deemed appropriate to overturn this decision."

Frazier–Ali Fight Triggers Broadcasters–Cable-TV Argument

The big fight was carried by closed-circuit TV into about 350 theaters in the U.S. and Canada at an average price per ticket of around $12. In addition, it was carried overseas by cable or satellite to some 35 nations. It also served to spark a fight between NAB (National Association of Broadcasters) and NCTA (National Cable Television Association). On the morning of the fight, NAB Executive V.P. Paul Haney said: "This fight, blacked out on free television and radio in America and around the world, is a shocking example of what cable-pay television is all about. It would be the height of tragedy if Americans failed to learn a lesson from tonight's closed-circuit gouge. What if the World Series or the Super Bowl or championship basketball followed this shabby cable-pay television pattern?" NCTA President Don. V. Taverner responded immediately. He said that the "NAB would do better to direct its remarks to the closed-circuit TV industry" and not use interchangeably the terms "closed circuit" and "pay-cable television." He said, "We cannot speak for pay television, but the record clearly indicates that cable systems have gained nothing from the blackout."

Bids for Domestic Communications Satellites

At least eight companies have filed plans with the FCC for permission to construct and operate a domestic communications satellite system. The systems will be used for nationwide telephone and television transmissions, and will employ a number of synchronous, stationary satellites located 22,300 miles above the earth. Companies that have filed with the FCC include: *Comsat, RCA, Western Union, Hughes Aircraft, AT&T, MCI Lockheed, Fairchild Hiller,* and *Tele-Communications.*

WWV to Change Program Format

Standard time and frequency radio stations WWV and WWVH plan to revise the formats of their broadcasts on July 1. Voice announcements of the time will be made every minute instead of every five minutes, male and female voices will be used to distinguish between the two stations, and all Morse-code signals will be eliminated. Only the content of the broadcasts will change; the carrier frequencies will remain the same. Each hour will be divided into one-minute slots; each minute (except the first) will begin with an 0.8-second

tone of 1000 Hz at WWV or 1200 Hz at WWVH. The first minute in each hour will begin with an 0.8-s tone of 1500 Hz at both stations. The minute slots will be divided into a 45-s segment and two 7.5-s segments: on alternate minutes the 45-s segment will contain either a standard tone (tentatively 600 Hz) or an announcement to be used by government agencies. Those announcement slots not used will be filled by another standard tone, probably 500 Hz. A special 440-Hz tone will be broadcast for 45 s beginning two minutes (for WWV) or one minute (for WWVH) after the hour.

First "Accredited Degree" in Engineering by Correspondence

What is said to be the first "accredited degree" in engineering to be granted by a private correspondence school in the U.S. has been awarded to Clayton Hallmark of Cincinnati, Ohio. In ceremonies conducted earlier this year, *Grantham School of Engineering* awarded the degree of Associate in Science in Electronics Engineering. The ASEE degree program consists of 400 correspondence lessons plus a two-week graduation seminar conducted at the school. This degree program was accredited in 1968 by the Accrediting Commission of the National Home Study Council.

Zenith Wins $19-Million Antitrust Suit from Hazeltine

After a long and involved history, the U.S. Supreme Court ruled in favor of *Zenith Radio* against *Hazeltine Research* in a $19-million antitrust suit. *Zenith* was awarded triple damages because a patent pool including *Hazeltine* prevented *Zenith* from going into the Canadian market with television sets and other products. Damages were awarded for loss of business for a period of four years prior to 1963.

FM Stations Sign for 4-Channel Stereo Broadcasts

Final arrangements have been made with *Bonneville International Corp.* to begin 4-channel stereo broadcasting on its line of FM stations. The *Electro-Voice* Stereo-4 encoding process will be used. The stations involved are KSL, Salt Lake City; KBIG, Los Angeles; KIRO, Seattle; KMBR, Kansas City; WCLR, Chicago; and WRFM, New York. In addition to these, no less than 17 other FM stations throughout the country have Stereo-4 encoders for their use on occasional, experimental broadcasts. Listeners with mono equipment will receive a full-range monophonic program, and those with 2-channel stereo receivers will be able to pick up complete 2-channel stereo signals. In order to reproduce the 4 channels, a special decoder plus two more amplifier channels and two more speakers will be required.

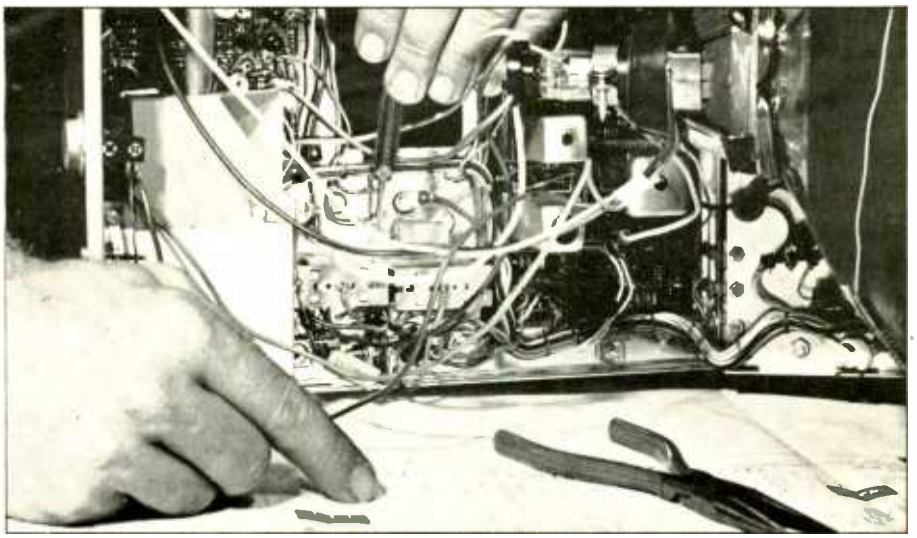
Radiation in Foreign-Made TV Receivers

Anyone planning to bring a foreign-made TV receiver into the U.S. following a trip abroad is advised by the Dept. of Health, Education, and Welfare to be sure that the set bears a label certifying compliance with the Federal limitation on x-ray emissions. The Radiation Control for Health and Safety Act requires any electronic product imported for sale or use in the U.S. to carry such a label. The labels must be affixed by the manufacturer on the basis of approved product testing procedures. The labeling requirement presently applies to television receivers and certain electronic tubes used in science instruction since control standards for these are now in effect. A microwave cooking oven radiation limitation will become applicable after October 6, 1971; in addition, anti-radiation standards are being presently developed for medical x-ray equipment.

Superconducting Device Measures Heartbeat

Measuring heartbeat without direct electrical or physical connections to the body has been achieved by scientists at the National Bureau of Standards Cryogenics Division. The instrument used generates electrical signals that are proportional to the heart's magnetic pulses when it is placed near the heart. When used to drive a scope or a strip-chart recorder, these signals provide a magnetocardiogram (MKG) of the heartbeat that is similar to an electrocardiogram (EKG). The MKG requires no electrodes to be attached to the patient's chest and does not require disrobing. It is also faster and more convenient than other methods. A drawback, however, is that the earth's magnetic field must be compensated for and measurements must be made away from magnetic fields produced by motors, power lines, or lab equipment. The device is a superconducting gradiometer which measures the difference of the magnetic field existing between two superconducting coils, one influenced by the earth's magnetic field, the other by the heart signals. The coils are contained within an insulating dewar and are submerged in liquid helium within a container of liquid nitrogen to maintain the very low temperature required. ▲

There is no substitute for training on real electronic equipment.



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You'll have it all over the man whose only experience has been on a TV receiver designed strictly for training purposes.

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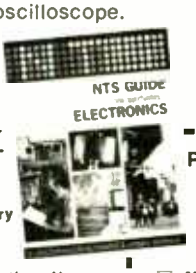

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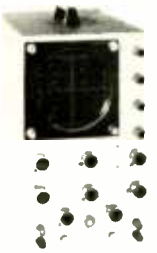

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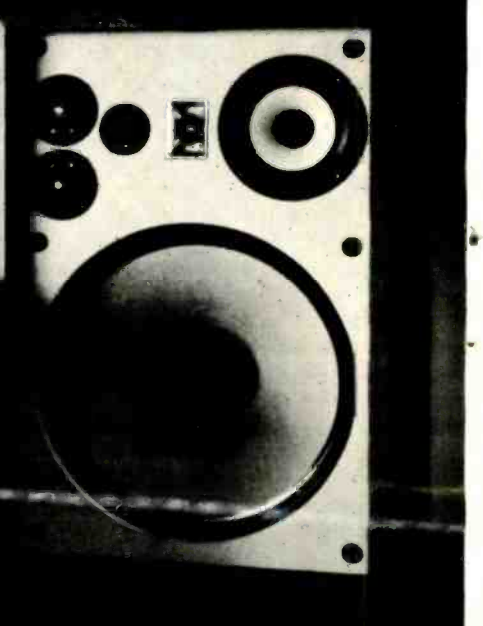
AA-6600/AA-8500



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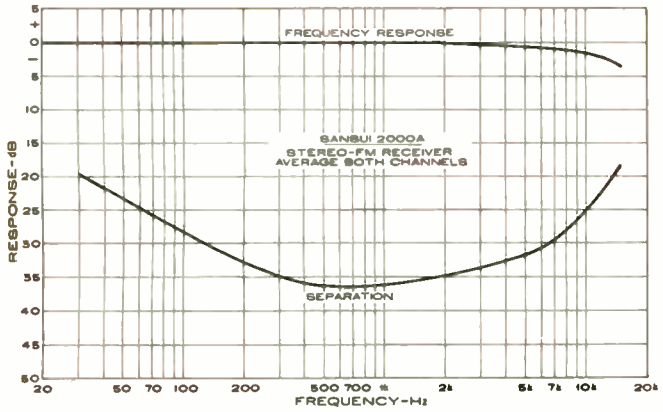

and amplifiers now on the market. The RIAA equalization was very accurate, within +0.8, –0.5 dB from 30 Hz to 15 kHz.

With both channels driven simultaneously, the 1000-Hz audio harmonic distortion was under 0.2% from a half watt to about 39 watts output. The IM distortion was typically under 0.3% over the same range. At the rated 35 watts per channel the harmonic distortion was under 0.5% from 55 Hz to almost 20 kHz, and less than 0.1% at mid-frequencies. Like most receivers, the power-supply capacitors of the Model 2000A limit the low bass continuous power output and cause a rapid rise in full-power distortion below about 50 Hz. However, the Model 2000A performed better in this respect at 35 watts than its predecessor did at 30 watts. At half power or less, the distortion was below about 0.3% from 20 Hz to 20 kHz, and typically less than 0.1%. At the clipping point, the Model 2000A delivered 42.5 watts per channel into 4 ohms, 35 watts into 8 ohms, and 22 watts into 16 ohms.

The FM tuner had an IHF usable sensitivity of 1.75 microvolts (rated 1.8 microvolts), with limiting complete at 10 microvolts. The stereo separation was excellent across the entire audio bandwidth, 20 dB at 30 Hz, 36.5 dB at mid-frequencies, and a good 18 dB at 15 kHz. The AM tuner sounded as good as one could expect, although of course not at all comparable to the FM quality. However, it was clean and free from birdies and other undesired noises.

The Model 2000A is not only an exceptionally handsome receiver, in our opinion, but it sounds as good as it looks. It is really a valid and worthwhile improvement over the already fine Model 2000, incorporating recent technological advances and offering somewhat improved performance at no increase in price.

The *Sansui* Model 2000A sells for $299.95, in a black metal cabinet. An optional walnut cabinet is available for $22.50. ▲

Rabco Model ST-4 Turntable/Arm

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

IT has long been recognized that an ideal record-player arm should maintain the cartridge axis tangent to the record groove at all times to minimize distortion caused by the pickup having a different orientation than the recording stylus. Many so-called "radial" tonearms have been designed, and a number of them have been manufactured, but most have suffered from excessive friction or other faults.

During the past couple of years, the *Rabco* servo-driven arm has been on the market and has been widely accepted as meeting some of the most critical requirements of record reproduction. However, the SL-8 arm is quite expensive, and only usable with a couple of types of turntables.

Rabco has now announced a combination turntable and radial servo-driven arm, whose combined price is less than that of the SL-8 arm alone. The new ST-4 record player employs an arm drive of elegant simplicity, together with a high-quality belt-driven two-speed (33⅓ and 45 r/min) turntable. It is supplied ready to use (except for the cartridge) on a walnut base and features a unique optional two-piece "clam-shell" plastic cover that requires less than one foot of vertical clearance even when opened.

The turntable of the ST-4 is a 5-pound zinc casting, 11½" in diameter. It is driven by a small, 600 r/min synchronous motor with a two-step shaft. A small lever in the rear shifts the belt to the appropriate shaft section for speed changes. To assist the motor in bringing the heavy turntable up to speed, the starting lever gives the platter a "shove" when the motor is started so that it reaches full speed in a couple of seconds. The turntable is fitted with an anti-static rubber mat.

An "O"-ring drive belt, driven from the turntable shaft, supplies the power to the arm servo. This is a shaft about ⅝" in diameter and 8" long at the rear of the unit. The arm, which is tangent to the record grooves, rests on this shaft through a small rubber wheel. The shaft rotates at 10 r/min. When the arm is tangent to the groove, the small wheel rotates freely with no effect on its position. As the stylus moves in along the record spiral, the rotating wheel carries the rest of the arm inward to maintain tangency. The entire process goes on continuously so that the arm is always correctly positioned, with only the minute error required by any servo system to control its operation.

To lift the arm from the record, a button on the motorboard is pressed. This energizes a second motor which raises a bar under the arm shaft to lift the rotating wheel clear of the shaft. In the raised position, the arm can be moved manually to any part of the record, or to one side for loading or removing a record. Pressing the button a second time lowers the pickup gently to the record surface.

The ST-4 has a unique photoelectric arm lift that raises the arm automatically at the end of the record. When the pickup reaches the eccentric groove at the end of play, it moves in faster than the servo can move. A mirror near the base of the arm reflects a light beam from a lamp in the motor area into a cadmium-sulfide photocell, which operates a relay to turn on the lift motor.

The arm is adjustable so that any cartridge can be positioned for tangency. Tracking force is set by balancing the

tonearm with a threaded counterweight and then backing off the counterweight by a predetermined amount for the desired force.

Laboratory & Use Tests

In using the ST-4, we found that the arm mass was so low that it would track severely warped records without losing contact with the grooves. In this respect, it was better than practically all pivoted arms we have used, and almost as good as the *Rabco* SL-8 arm, which is outstanding in this test. The effective vertical pivot of the ST-4 arm is very nearly in the record plane and this, combined with its length of 7", makes it quite insensitive to warp wow.

Not only is there no tracking error with this arm, but the absence of an offset to the cartridge completely eliminates skating forces and the need for any corrective systems. We verified this with high-velocity test records, which showed identical waveforms on both channels. Pivoted arms require correct anti-skating compensation to achieve this condition. The ST-4 is not critical with respect to leveling; in fact, we operated it at angles as great as 15 degrees to the horizontal with no detectable change in its performance.

Our tests were made with a *Stanton* 681EE cartridge, operating at 1 gram. It is evident that this arm will operate at the lowest forces usable with any current cartridge. No resonance was detected in the sweep from 200 Hz to 10 Hz.

The measured wow and flutter were, respectively, 0.10% and 0.035% at 33⅓ r/min. At 45 r/min, they were slightly lower; 0.08% and 0.025%. The unweighted rumble was –30 dB (lateral plus vertical) and –32 dB with the vertical component cancelled out. With *CBS* RRLL weighting, the rumble was a very low –55 dB, reflecting the fact that it was principally at 10 Hz, the basic motor rate. The turntable, motorboard, and arm structure are suspended from the base on compliant mounts, isolating them from external shock and vibration. The drive motor and the push-button that operates the arm lift are rigidly mounted to the wooden base so that the system is well isolated from motor vibration and there is no tendency to bounce the arm when pushing the arm-lift button.

It takes only a short while to become used to the rather unconventional operation of the ST-4. The absence of a finger lift means that the arm must be visually positioned over the desired portion of the record. It descends in a straight line so that with a little practice, one can drop it in the correct spot without difficulty. It would be convenient if a finger lift were provided for final cueing, but at present there is none.

It seems fair to ask how the ST-4 compares with *Rabco's* deluxe SL-8 arm. Obviously, the lower cost of the ST-4 is due to a combination of the simple, yet ingenious, arm-drive system and the fact that the power to drive it comes "free" from the turntable. The ST-4 arm lacks some of the operating conveniences and design sophistication of the SL-8, although one would be hard put to detect differences in their performance. On the other hand, the SL-8 can be used with certain premium-priced, highly refined turntables, while the ST-4 is a complete package.

It should suffice to say that the ST-4 brings the essential advantages of a radial arm to a reasonable price range, together with an excellent turntable and without the need to do any assembly or critical adjustments. It works, in every respect, just as it was designed to and should be a very reliable piece of equipment, judging from its basic simplicity and rugged construction. It is rather bulky (in depth) with base dimensions of 15" wide by 18⅛" deep. Although only 11½" of vertical clearance is all that is needed to open the "clam-shell" cover, this necessitates additional side clearance, for a total installation width of 21⅞".

The price of the *Rabco* ST-4 record player is $159.95. The optional cover is $15. ▲

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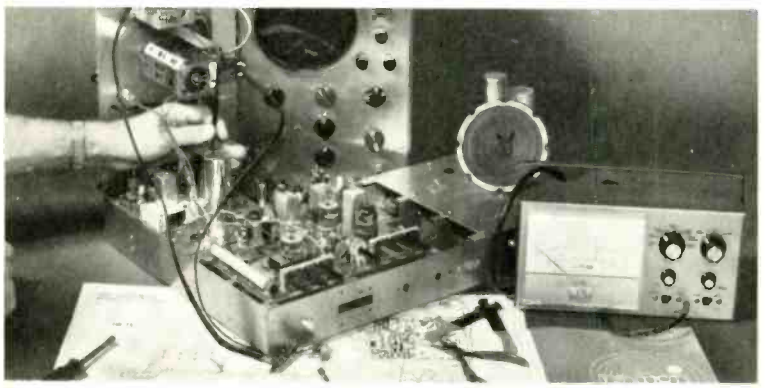

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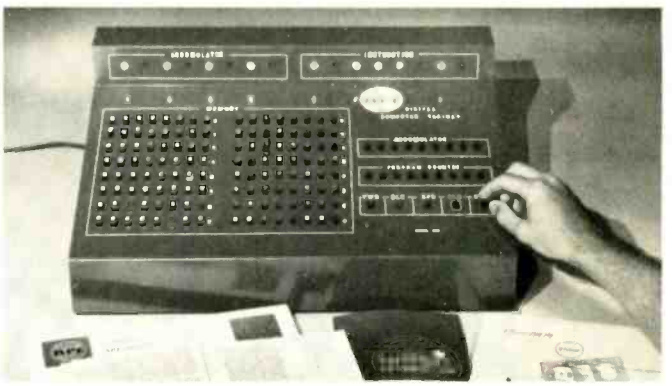

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LETTERS

COLOR-TUBE FACEPLATES

To the Editors:

On page 25 of the February, 1971 issue ("Color-TV for 1971") an incorrect statement is made regarding the glass *Corning* uses for color-tube faceplates.

We introduced strontium color-tube faceplates with high x-ray absorption in 1969. Only naturally occurring strontium materials are used, and these do not contain the highly radioactive strontium-90. As you know, strontium-90 is a man-made isotope and is a product of nuclear explosions.

We have had an inquiry from one of your readers who did not seem concerned but who wished to have the matter clarified. It is possible, of course, that other readers may be unnecessarily alarmed by your story.

JOHN L. SHELDON, Research Manager
TV Prod. Div., *Corning Glass Works*
Corning, N. Y.

* * *

VOLT-OHM-MILLIAMMETERS

To the Editors:

I have been a reader and part-time subscriber to your magazine since it was called "Radio News." I would like to comment on the article in the March issue on volt-ohm-milliammeters.

One of the things I have wanted for many years is a set of scales on a v.o.m. that would fit the readings found in actual equipment instead of "laboratory" ranges as are so often found in most meters offered today.

I first noticed these ranges on an old *Jewell* a.c. voltmeter. They worked out so that almost every reading found in various pieces of electrical equipment would normally be in the upper half of the scale. I eventually fitted this instrument up as a knock-about multi-range a.c. meter with 0-4, 0-8, 0-16, 0-40, 0-160, 0-400, and 0-800 V capability.

Later on I bought one of the first *Simpson* Model 269 meters, mainly because it used this format on the ranges but also because it had a sensitivity that eliminated the necessity for the use of a v.t.v.m.

If we were to have a .4 V and perhaps a .16 V range along with the lower current drain of the v.t.v.m., this would give us the ideal service instrument.

There is another need that I found while employed by a utility company in their meter shop. I had occasionally needed this device while testing sound-system wiring while standing on a ladder. However, after sending the same meter in several times for repair, after a lineman had dropped it while making tests many feet above the ground, I seriously considered trying to make up a meter which would hang around the neck on a strap with the scale facing upward. This instrument would be used mostly for low-voltage and continuity tests. It could use the rotary dial scale found on a certain make of clamp-on volt-ammeter, or a lever-type switch with several positions.

E. M. SMITH
Mesa, Ariz.

* * *

SPEED CONTROL FOR MOTORS

To the Editors:

I was most interested in the article on "Speed Control for Large D.C. Motors" by Lawrence Fleming (January, 1971 ELECTRONICS WORLD).

From the author's diagram, I see that he is using silicon rectifiers, which are good. I have serviced commercial systems of similar design and found that the systems having silicon rectifiers were more reliable than those using selenium rectifiers. The selenium rectifier's resistance seems to increase with age, thus causing the motor to run slower.

RAYMOND E. SIDES, JR.
Jackson, Miss.

* * *

ELECTRONIC SECURITY SYSTEMS

To the Editors:

We refer to John Frye's article entitled "Electronic Security Systems" which appeared in the February, 1971 issue of ELECTRONICS WORLD.

Would you please send us the addresses of all the concerns mentioned in this article so we may contact them for literature and distributor pricing for their products.

SID LEVIN
San Francisco, Cal.

Since Mr. Frye's column was not intended as an in-depth feature article, we did not feel complete addresses were necessary. However, there has been so much reader interest in the subject, we include this information here:

Aerojet Delft Corp.
Box 966
Azusa, Cal. 91702

Acron Corp.
1209 River Ave.
Lakewood, N. J. 08701

Bourns-Euphonics
681 Old Willets Rd.
Smithtown, N. Y. 11787

Defensive Instruments
925 Penn Ave.
Pittsburgh, Pa. 15221

Delta Products, Inc.
Box 1147
Grand Junction,
Colo. 81501

Entron, Inc.
2141 Industrial Pky.
Silver Spring, Md. 20904

GC Electronics Div.
Hydrometals, Inc.
400 S. Wyman
Rockford, Ill. 61101

Guardsmark, Inc.
270 Park Ave.
New York, N. Y. 10017

James Electronics
4050 N. Rockwell
Chicago, Ill. 60618

LaBarge, Inc.
7501 S. Broadway
St. Louis, Mo. 62111

Mallory Co.
3029 E. Washington St.
Indianapolis, Ind. 46206

Management Safeguards
347 Fifth Ave.
New York, N. Y. 10016

Motorola, Inc.
9401 W. Grand Ave.
Franklin Park, Ill. 60131

MRL, Inc.
215 Mill, N.E.
Falls Church, Va. 22000

Radar Devices
22003 Harper
St. Clair Shores,
Mich. 48080

Robotguard, Inc.
6140 Germantown Ave.
Philadelphia, Pa. 19144

Westinghouse Security
Systems, Inc.
Box 8606
Pittsburgh, Pa. 15221

This list is by no means complete; new companies are entering the field of electronic security systems almost daily.—Editors

* * *

SOLID-STATE THERMOMETER

To the Editors:

In reference to Gordon Gregg's article (March, 1971 ELECTRONICS WORLD) entitled "Solid-State Probe Thermometer," a fundamental physics error is made under "Calibration." The statement that a mixture of ice and water will remain between 33°-40° F is incorrect. The temperature of the mixture of ice and water is *exactly 32°F* because the transfer of heat keeps the temperature constant until the mixture is either all ice or all water. The physical phenomenon involved is the "heat of fusion" and, for ice, this is 80 calories per gram.

I have built the probe thermometer with good results. I used a 9-V transistor radio battery and a 2N3638 base-to-emitter junction for the 6-V zener—also a push-to-read switch.

PAUL GALLUZZI, P. E.
Beverly, Mass.

The temperature of melting ice is indeed 0°C (32°F) but, to get it accurately, you should use an insulated container and a stirring machine. In an ordinary glass with hand stirring, the temperature takes quite a while to get to equilibrium since heat is constantly escaping and you have to keep adding ice. Since all that is needed is to subject the probe and the reference thermometer to the same temperature, it is okay in practice to make the comparison before equilibrium is fully established, say at 33° or 36°F or thereabouts.—Editors ▲

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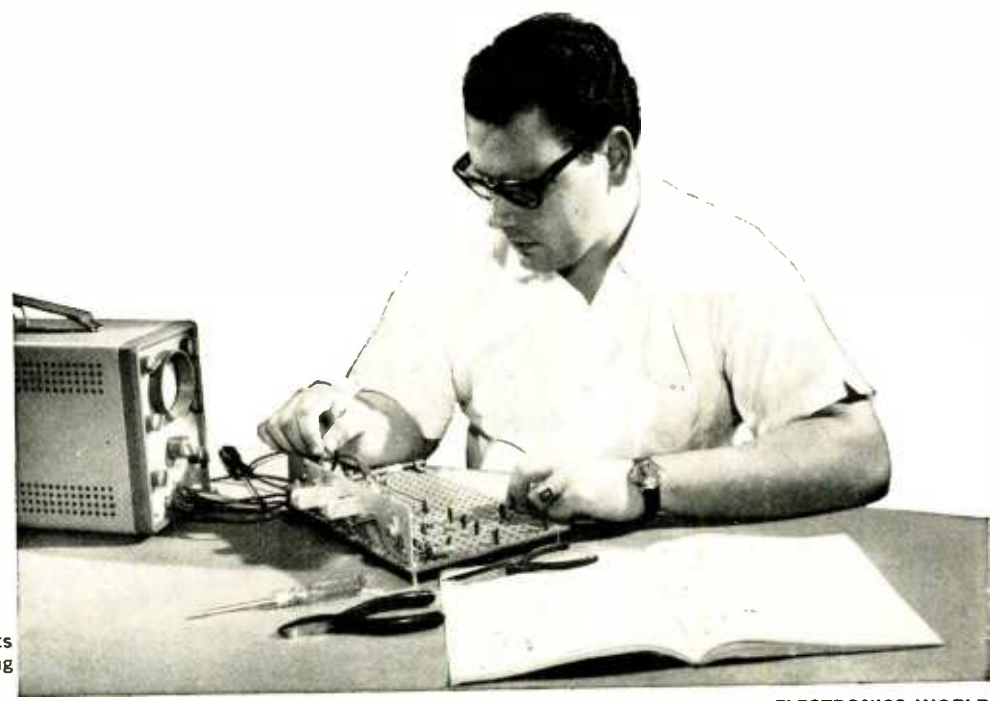

Performing transistor experiments on programmed breadboard — using oscilloscope.

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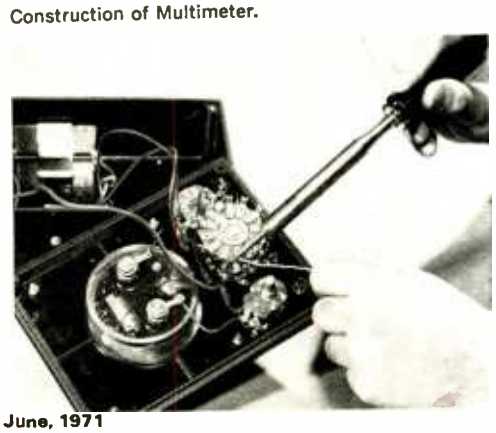
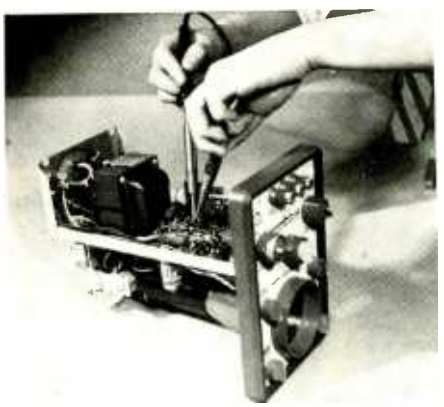
RCA

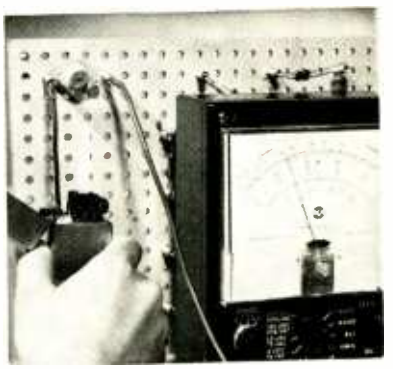
Construction of Multimeter.

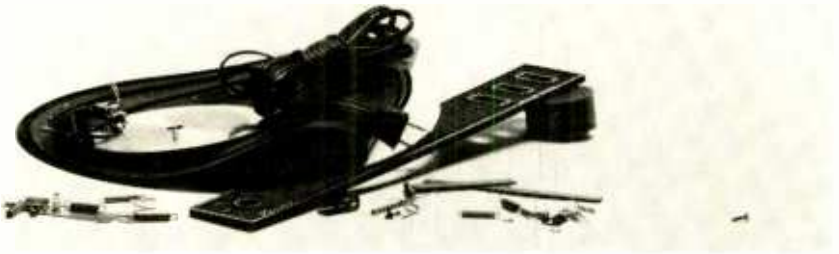




Construction of Oscilloscope.

Temperature experiment with transistors.





There are 202 parts in a Garrard automatic turntable.

We make all but a piddling few.

Today's automatic turntable is a beastly sophisticated device.

The Garrard SL95B, below, has 202 different parts.

That is, unless we tally the "parts" that go into such final assembly parts as the motor and pickup arm. In which case the total is more like 700.

A few of these parts we buy. Mostly springs, clips and bits of trim.

But the parts that make a Garrard perform, or not perform, we make ourselves.

To buy or not to buy

At our Swindon works, in England, a sign reads "If we can't buy surpassing quality and absolute accuracy, we make it ourselves."

E. W. Mortimer, Director of Engineering Staff and a Garrard employee since 1919, says "That sign has been there as long as I can remember.

"But considering the precision of today's component turntables, and the tolerances we must work to, the attitude it represents is more critical now than it was even ten years ago."

Our Synchro-Lab motor is a perfect example.

To limit friction (and rumble) to the irreducible minimum, we superfinish each rotor shaft to *one micro-inch*.

The bearings are machined to a tolerance of plus or minus one ten-thousandth of an inch. Motor pulleys must meet the same standard.

"When you make them yourself," observes Mr. Mortimer "you can be that finicky. That, actually, is what sets us apart."

Mass produced, by hand

Despite its place as the world's largest producer of component automatic turntables, Garrard stubbornly eschews mass production techniques.

Every Garrard is still made by hand.

Each person who assembles a part tests that finished assembly.

And before each turntable is packed in its carton, 26 final tests are performed.

Thus, we're assured that the precision achieved in its parts is not lost in its whole.

Swindon, sweet Swindon

In fairness to other makers, we confess to a special advantage.

Our home.

At last census the total population of Swindon, England was 97,234. Garrard employs a rather large share of them, and has for fifty years.

"Not everyone has been here from the year one as I have," smiles Mortimer "but we have 256 employees with us over 25 years. Many are second and third generation.

"It's hardly your average labor force. Everyone feels a part of it."

The sum of our parts

Today's SL95B is the most highly perfected automatic turntable you can buy, regardless of price.

Its revolutionary two-stage synchronous motor produces unvarying speed despite extreme variations in line voltage.

Its new counterweight adjustment screw lets you balance the tone arm mass to within a hundredth of a gram.

Its patented sliding weight anti-skating control is permanently accurate.

And its exclusive two-point record support provides unerringly gentle record handling.

You can enjoy the SL95B, the sum of all our parts, for $129.50.

Or other Garrard component models, the sum of fewer parts, for as little as $44.50.

Your dealer can help you decide.

Garrard

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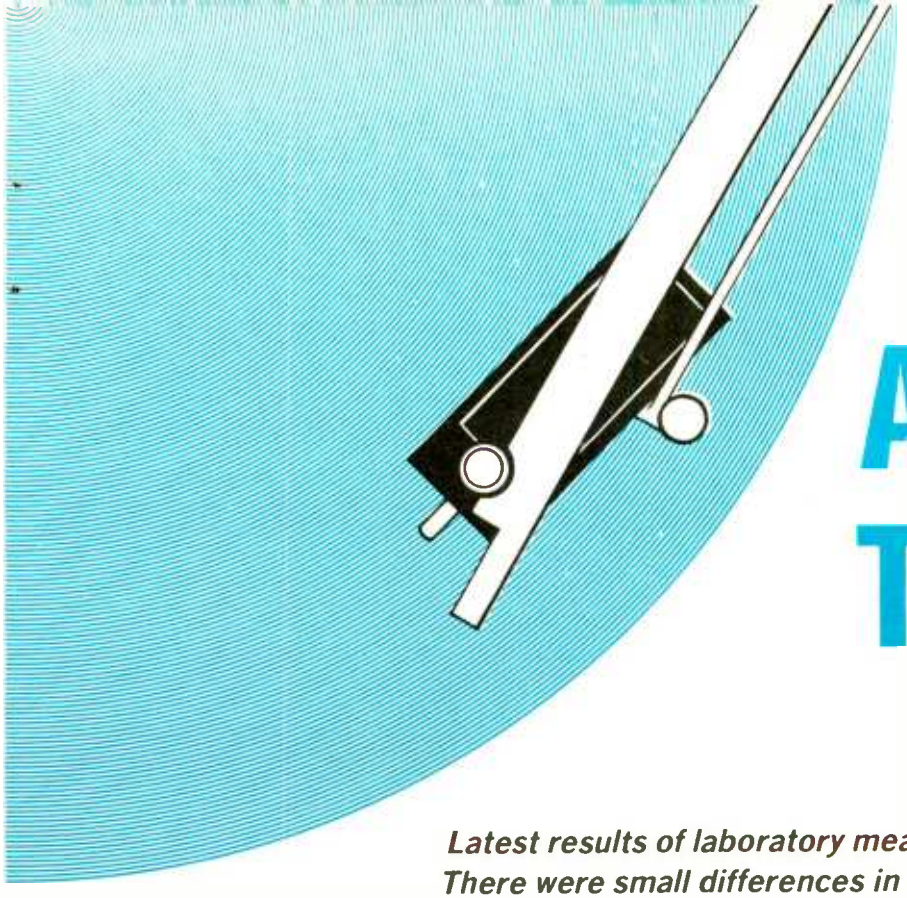


Hirsch-Houck Lab Tests

Automatic Turntables

By JULIAN D. HIRSCH

Latest results of laboratory measurements on 21 units suitable for hi-fi. There were small differences in performance, with higher priced models incorporating a number of refinements and more convenience features.

IN the June, 1970 issue, we reported on our tests of 17 automatic turntables, comparing their performance and design features. Apparently the record player (at least in a marketing sense) is one of the more stable hi-fi components, since most of last year's models are still available. However, there have been several additions, as well as a few models superseding those we tested last year.

Although most of the new turntables could hardly be described as innovative, some design trends are evident. In the higher priced units, the adjustable vertical cartridge angle, introduced originally by *P-E* and *Dual*, is now featured in the top-of-the-line models from *Miracord* and *Garrard*.

In the past, record players having a vernier speed adjustment were supplied with a small stroboscopic disc that could be slipped over the turntable spindle for setting exact speeds. This is a necessary procedure with adjustable-speed turntables, but it is often overlooked because of the inconvenience of adding and removing the strobe disc and the necessity for viewing it under fluorescent or neon light. Two of the new turntables (*Garrard* Zero 100 and *Miracord* 770H) have borrowed a feature from some of the most advanced single-play turntables and have stroboscopic markings around the periphery of the platter, continuously illuminated by a neon lamp and always visible to the user.

The "Total Turntable" concept featured by *BSR/McDonald* has been continued in its new line. Although these turntables can be purchased without accessories, they are also sold in complete, ready-to-play form. A suitable cartridge is installed, the record player is mounted on a plastic base, and a plastic dust cover is furnished. Some *Garrard* models (not included in this survey) are similarly packaged.

The new *Garrard* Zero 100 features a radically new tonearm, which we will describe in more detail later on.

The June, 1970 article contained detailed descriptions of all the turntables and of our test procedures. Since most of that information is still valid and too lengthy to repeat here, we suggest that you refer to that issue. The tabular presentation of our original data is up-dated here, for those models still available, plus similar data on the new units.

Important Characteristics

The salient characteristics of a record-playing turntable are its rotation at a constant (and correct) speed, freedom from short-term speed fluctuations which produce the audible effects known as "wow" and "flutter," and low mechanical vibration, which is sometimes heard as "rumble."

Absolute speed accuracy is usually relatively unimportant as long as it does not cause a detectable pitch error. Speed errors of 1% or less are generally tolerable. If exact pitch is important, some turntables have a vernier speed adjustment with a range of several percent.

This year we used a *Heath* IB-101 frequency counter to verify the speed accuracy of the turntables, playing a record having an accurately known recorded frequency.

Speed fluctuations occurring at rates between 0.5 Hz and 10 Hz give rise to the characteristic sound of "wow." A wow percentage of 0.2% may be audible on sustained notes, such as those of a pipe organ or the decay of a piano note, but will rarely be offensive. Less than 0.1% wow cannot be heard, as a rule. "Flutter" is a similar effect, occurring at rates between 10 Hz and 300 Hz. Its subjective effect varies widely, from a "gargly" sound in extreme cases (such as 0.5% or more flutter) to a subtle loss of clarity in less severe cases. Normally, a flutter percentage of less than 0.1% will not be heard.

Wow and flutter (unweighted) were measured with special test records and a *Donner* 2800 wow and flutter meter. Rumble was measured in accordance with NAB standards, using 1.4 cm/s at 100 Hz as a reference level and RIAA low-frequency playback equalization. In addition to measuring the combined vertical and lateral (V + L) rumble, which is the amount present in each channel, we also measured it with both channels paralleled to cancel out the

SUMMARY OF TEST RESULTS

Mfgr. & Model	Speed (r/min)	Accuracy	Line-Volt. Effect	Turn-table Dia. (in)	Turn-table Wgt. (lb)	Arm Length (in)	Arm Balance	Adj. Cart. Over-hang	Force Change Over 5/8" Stack (g)	Change Cycle Time (s)	33 r/min Wow (%)	33 r/min Flutter (%)
BSR-McDONALD												
310/X [1]	16,33,45,78	exact	none	10 1/8	n.a.	6 1/2	no	no	–0.5	8.0	.20	.080
510/X [2]	same	+0.3%	none	11	n.a.	6 3/4	yes	no	–0.2	8.0	.10	.050
610/X [3]	same	exact	none	11	3 1/2	6 3/4	yes	no	+0.3	8.0	.10	.045
DUAL												
1209	33,45,78	adj.	none	10 1/2	4	7 1/4	yes	yes	–	–	.10	.035
1215	same	adj.	1%	10 3/8	3 1/4	7 1/4	yes	yes	–	–	.10	.030
1219	same	adj.	none	12	7	8	yes	yes	–	–	.06	.030
GARRARD												
40B	33,45,78	exact	2%	10 3/8	1 3/4	6 3/4	no	no	–	–	.20	.060
SL55B	same	exact	none	10 3/8	1 3/4	6 3/4	no	no	–	–	.08	.055
SL65B	same	exact	none	10 1/4	2	7	yes	no	–	–	.15	.040
SL72B	same	exact	none	10 1/2	1 3/4	7 1/2	yes	no	–	–	.07	.035
SL95B	same	exact	none	11 3/8	3	7 1/2	yes	no	–	–	.07	.030
Zero 100 [4]	33,45	adj.	none	11 1/2	n.a.	7 5/8	yes	yes	+0.5	9.0	.07	.025
MIRACORD												
50H	16,33,45,78	exact	none	12	5 1/2	7 1/4	yes	yes	–	–	.10	.040
620U	same	slightly fast	none	10 1/4	3	7 1/8	yes	yes	–	–	.12	.040
630	same	exact	none	10 3/8	5	7 1/8	yes	yes	–	–	.08	.035
750	same	slightly fast	very slight	12	5 1/2	7 1/4	yes	yes	–	–	.03	.035
770H [5]	33,45,78	adj.	none	11 7/8	6 1/2	7 1/2	yes	yes	+0.2	13.0	.06	.025
PERPETUUM-EBNER												
2010 [6]	16,33,45,78	–0.5%	1.8%	10 5/8	n.a.	7 1/2	no	no	+0.5	14.0	.045	.025
2035 [7]	33,45,78	adj.	1.5%	10 1/2	n.a.	7 1/2	yes	yes	+0.4	17.5	.13	.04
2038	same	adj.	very slight	10 1/2	4 1/4	7 3/8	yes	yes	–	–	.08	.05
2040	same	adj.	very slight	11 3/8	7 (est.)	7 3/8	yes	yes	–	–	.08	.04

Notes: n.a.=not applicable or not available; *includes cartridge, base, and dustcover. **coupled to stylus force; arm length=turntable center to arm horizontal pivot;

All products shown are currently in the lines of the five manufacturers. The models shown in color are the

vertical component. The remaining lateral rumble is what would be heard in mono playback.

The subjective effect of rumble is a function not only of its level but of its frequency content. Vibration at 30 Hz or higher frequencies, commonly found in turntables driven by four-pole motors operating at 1800 r/min, is more audible than much stronger vibration at subsonic frequencies. The standard NAB method of rumble measurement does not make any distinctions as to frequency. Over a rather wide band of frequencies, the measurement is concerned only with total amplitude of the vibration.

A weighting curve can be applied to the measurement to reduce the effect of the lower frequencies which are less audible. One such curve is the *CBS* RRLL (Relative Rumble Loudness Level), which essentially attenuates the rumble at 6 dB/octave below 500 Hz before measurement. The result is more indicative of the audibility of rumble than an unweighted measurement. However, since very low frequencies can overload some speakers and amplifiers and become audible by modulating higher frequencies in the program, both types of rumble measurement are important.

This year we measured rumble with the *CBS* RRLL weighting as well as unweighted, using a reference level of 3.54 cm/s per channel at 1000 Hz (corresponding to a lateral velocity of 5 cm/s). A weighted rumble of less than –50 dB will be inaudible in practically all cases and indicates a good-quality turntable. Levels of about –55 dB or lower have been found in a few of the quietest models we have tested. Since the acoustic properties of the listening room and the loudspeaker can have a profound effect on the audibility of rumble, the measured figures can serve merely as a rough guide to the relative quality of the turntables. Small differences between models have no significance.

There is little correlation between RRLL and unweighted figures. We have found unweighted levels of –35 dB to –40 dB in the quietest turntables, but some in the –25 dB to –30 dB range have proven in practice to be quite rumble-free. However, in such cases, the weighted rumble is almost always below –50 dB, indicating a preponderance of subsonic frequencies in the turntable vibration.

Rumble, wow, and flutter are often loosely related to the mass of the turntable platter (the heavier the better), but there are numerous exceptions to this rule.

The Tonearm and Cartridge

The task of the tonearm is to support the cartridge, maintaining its axis as nearly as possible along a line tangent to the record groove and with its body or other reference plane parallel to the surface of the record. Most cartridges, when so installed, provide the industry standard 15-degree vertical tracking angle.

The stylus tracking force, although primarily determined by the cartridge design, can also be affected by friction in the arm pivots. The frictional force, referred to the stylus tip, should be less than 10% of the vertical tracking force. Some inexpensive arms, whose pivots have relatively high friction, must be used with cartridges capable of operating at several grams. The finest cartridges, which track at 1 gram, can only be installed in a carefully designed arm with very low pivot friction.

Rumble (V + L) (−dB)	Rumble (L) (−dB)	Wtg'd Rumble (RRLL) (−dB)	Max Record Stack	Max. Tracking Error (°/in)	Max. Tracking Error (radius)	Max. Tracking Force Error (g)	Cueing	Anti-skating (optimum vs recom. setting)	Price ($) Less cart. and base	Comments
21.5	25.5	47.0	6	0.80	3.0	n.a.	undamped	OK	80*	[1]Force factory set @ 3.8 g; more than 0.1 g vert. arm friction; cartridge drifts on cueing drop
26.5	32.0	50.0	6	1.00	3.0	0.25	damped	not enough	100*	[2]Test @ 4 g; auto arm lock
25.0	27.0	49.0	6	0.70	3.0	0.30	damped	+1 to 1.5 g	142*	[3]Test @ 2 g; auto arm lock
35.0	43.0	–	6	0.80	–	0.10	–	–	130	
38.0	40.0	–	6	0.40	–	0.20	–	**	100	Test data applies to Model 1212 (see text)
39.0	40.0	–	6	0.40	–	0.25	–	–	175	
35.0	38.0	–	8	1.00	–	n.a.	–	–	45	
35.0	38.0	–	8	1.00	–	n.a.	–	–	60	[4]Tested with Shure V15/Type 11; speed adj. ±4%
27.0	30.0	–	8	1.00	–	0.25	–	–	75	(†Pre-production sample tested with incorrect arm setting. Mfgr. claims zero tracking error.)
38.0	43.0	–	8	0.40	–	0.30	–	–	100	
39.0	43.0	–	6	0.80	–	0.15	–	–	140	
32.0	33.5	53.5	6	0.40†	2.5	0.15	damped	OK	190	
37.0	39.0	–	10	0.50	–	0.05	–	–	175	
35.0	37.0	–	10	0.50	–	0.10	–	–	100	
38.0	40.0	–	10	0.60	–	0.15	–	–	130	[5]Tested with Elac ST-444E @ 1 g;
38.0	39.0	–	10	0.80	–	0.18	–	–	150	sync motor, speed adj. +1.8%, −3.6%
28.5	30.5	52.5	10	0.33	6.0	0.30	damped	OK	225	
29.5	35.0	54.0	10	0.50	4.0	n.a.	damped	n.a.	80	[6]Tested with Grado FTE @ 2 g
29.0	37.0	54.5	10	0.40	2.5	0.10	damped	**	100	[7]Tested with Grado FTE @ 2 g;
32.0	37.0	–	8	0.70	–	0.05	–	–	125	speed adj: +4%, −1.8%;
39.0	42.0	–	8	0.67	–	0.15	–	–	155	anti-skating correction insufficient

tracking error=between 2.5 and 6-inch radius, unless otherwise specified, in degrees per inch; tracking-force error=between 1 and 3 grams.

ones that have been introduced most recently. Note that we have performed several additional tests on these.

Except in the lowest price range, the arm and cartridge mass are balanced by an adjustable counterweight and a spring is used to supply the downward force, which is read on a calibrated scale. It is especially important at low tracking forces that the calibration of this scale be accurate, since a variation of a few tenths of a gram at a 1-gram setting could seriously affect cartridge performance. In an automatic turntable, it is also important that the vertical force not change significantly between the first and last record of a stack.

All automatic record players used pivoted arms, with an angular offset to minimize tracking error. Longer arms generally produce lower tracking error and correspondingly less distortion from that source. The distortion due to tracking error is proportional to the angular error divided by the playing radius. Even a relatively high error, such as 1 degree/in, will rarely cause any audible distortion. Most arms have much lower errors, frequently 0.5 degree/in or even less.

Tracking error can be drastically affected by very small shifts in the position of the stylus relative to the arm pivot and the turntable center. Although there is general standardization of cartridge-mounting dimensions, the best arms have some means of adjusting the cartridge in its shell to minimize tracking error.

Any pivoted arm with an angular cartridge offset is subject to skating force due to the friction between the stylus and the record surface. This tends to carry the arm towards the center of the record and can cause one stereo channel to have more distortion than the other. Most arms incorporate anti-skating devices that supply an opposing force to equalize the distortion in the two channels. Frequently, the anti-skating control is calibrated to match the stylus-force adjustment and the two are set for the same reading. The optimum correction is dependent on the record material, stylus size and shape, and vertical tracking force among other things. Although the amount of anti-skating correction provided by many arms is somewhat less than optimum, it is always in the right direction to improve performance. Precise anti-skating correction is only important when using a cartridge at the lowest tracking force and playing recorded material having very high velocities.

To check the effectiveness of the anti-skating compensation, we played a record having 1000-Hz tones recorded at the extremely high velocity of 30 cm/s. Skating force causes unequal distortion in the two channels. The anti-skating adjustment was varied until the channels had similar waveforms and its setting was compared to the manufacturer's recommended value.

Other factors, which would have no effect on the audible performance of a record player, relate to its convenience or flexibility of operation. These include the cueing control, which lifts the pickup from the record and lowers it to the same point at a later time. Some cueing devices (in the lower priced units) are undamped so that the arm will rise or fall just as rapidly as the cueing lever is moved. More gentle operation results from a damped cueing system which moves the pickup slowly and prevents it from contacting the record violently, no matter how carelessly it is used. The number of records that can be stacked in auto-

BSR-McDonald 610/X ▶

◀ Dual 1215

Garrard Zero 100

Miracord 770H

Perpetuum-Ebner 2035

matic play varies from 6 to 10 and the time required for a record to change can range from about 8 to 18 seconds. Some arms have well-designed finger lifts, like a good manual tonearm, while others are difficult to position manually.

BSR-McDonald

The 400, 500A, and 600A models tested last year have been superseded. We tested the 310/X, 510/X, and 610/X. The "X" signifies a "Total Turntable" package; the same units are also available without base, cover, and cartridge.

All *BSR* turntables provide four-speed operation. Their operating speeds are very close to exact and do not change with line voltage, although they use four-pole induction motors. Their arms are relatively short and have a correspondingly higher tracking error than other players with longer arms. However, their tracking error was not large enough to be detrimental to their sound quality. The arm of the 310/X is unbalanced; the two higher priced models have adjustable counterweights.

The 310/X has a light, drawn platter 10⅛" in diameter. The 510/X and 610/X have 11" platters; the former is of drawn construction and the latter is a casting weighing about 3½ lb. All of the *BSR* turntables have an unusually short change cycle of 8 seconds.

The cueing system of the 310/X is undamped, requiring careful lowering of the arm. There was outward drift of the pickup as it descended due to the anti-skating torque. The other *BSR* models have a damped lowering action and negligible outward drift.

The 510/X and 610/X have an automatic arm lock feature which clamps the arm whenever it returns to the rest. The 310/X and 510/X have single anti-skating adjustment scales calibrated from 2 to 6 grams; the 610/X, in addition, has a scale calibrated for elliptical styli over a 2- to 4-gram range.

The type of cartridge supplied in each system is a good indication of the capabilities of its tonearm. The 310/X and 510/X operate very well at 4 grams tracking force with the *Shure* M75, while the 610/X is well matched to the 2-gram operation of the *Shure* M93D. An extra convenience feature of the 610/X is the power-control base which allows the record player to switch the associated amplifier on when it is started and turn it off when playing is completed.

Garrard

All of *Garrard's* 1970 models are still current. The new Zero 100 is a radical departure from previous practice. It features an articulated tonearm which pivots the cartridge shell laterally as it plays a record to maintain a negligible tracking error. This gives the effect of a very long arm, but without its increased mass and within the confines of a normal-sized record player.

Unlike other *Garrard* models, the Zero 100 has a cartridge slide which permits accurate positioning of the cartridge for minimum tracking error and a plastic jig is supplied for making this adjustment. A lever on the cartridge slide tilts the cartridge vertically to maintain the preferred 15-degree vertical tracking angle when playing a single record or at the center of a stack of six records.

Many of the operating features and controls of the Zero 100 resemble those of the Model 95B, including a "Synchro-Lab" motor and viscous-damped cueing system. There are, however, a few notable differences. The Zero 100 has a vernier speed control with a range of nominally ±3%. Its platter has illuminated stroboscope markings, visible through a window on the motorboard.

Anti-skating correction is necessary in spite of the near-zero tracking error, since the arm is pivoted and has an offset cartridge angle. A novel method is used to apply the correction. Two ceramic disc magnets—one on the tonearm gimbal and the other on the fixed pivot support—repel each other to apply an outward thrust to the arm. The amount of thrust is controlled by a ferrous magnetic shield between the magnets. The anti-skating control, with separate calibrations for conical and elliptical styli, shifts the position of the magnetic shield between the magnets and thus controls their repulsive force.

Miracord

Miracord's new Model 770H enjoys the distinction of being the most expensive automatic turntable currently available. The 770H was received with an *Elac* ST-444E cartridge, not normally supplied, which we operated at 1 gram. Although basically similar to the Model 50H, it features a vernier speed adjustment and an unusual illuminated stroboscope built into the turntable platter structure. Instead of the customary dot or line pattern, the user sees a stationary row of numerals ("33" or "45" depending on the turntable speed) when the speed is correct. There is also a 78 r/min speed, which will be correct when one of the lower speeds has been set accurately.

The cartridge slide of the 770H has a lever that tilts the cartridge vertically for optimum vertical tracking angle. It

(Continued on page 69)

Electronic Bartender

By FRED W. HOLDER

This system mixes cocktails, records purchases, and maintains precise liquor inventory without backtalk or conversation.

IF the bartender in your favorite pub seems too slow, you'll look forward to seeing *NCR's* new Electra-Bar installed there. This new system mixes cocktails, records purchases, and maintains a precise liquor inventory in less than two seconds.

It's capable of concocting 36 kinds of cocktails and highballs. It measures the liquor content of drinks in one-eighth ounce increments from 1 to 2½ ounces as required by a particular drink. Other ingredients are dispensed in even smaller amounts. As shown in Fig. 1, the system is made up of five separate units.

The control register has 36 drink keys, punched by the human bartender, which trigger the automated dispensing mechanism, plus all the regular cash-register functions. The 36 drink keys are unique in that some of them provide for automatically dispensing the most popular cocktails in exact recipe portion; for example, Manhattan, martini, sour, etc. The remaining keys are programmed to automatically dispense the prime ingredient in the exact portion for highballs or most other cocktails a customer may order. The cash-register portion of the unit provides all conventional controls applicable to bar systems such as totals for service, checks paid, charge, and charge tips. Department sales totals and preset price keys are also included.

The logic unit contains all of the electronic circuitry required for timing and control. Essentially, this is the computer portion of the system. The logic unit connects to the control register, the bottle racks, and the dispensing head. It accepts one of the 36 individual drink commands from the control register and causes the appropriate ingredients to be dispensed in predetermined amounts to the exact eighth of an ounce. At the same time, the ounce counter in the logic unit automatically subtracts the amount of liquor used from inventory. Transaction counters at the bottom of the register keep a running tally of beverage units served in each price category.

The bar has two identical bottle racks, each holding six bottles. Each bottle position has a red warning light which signals when the contents of the bottle are exhausted. Also, a signal is sent to the control register to lock out all drink keys that are affected by that bottle. The 12 bottles used in the system consist of nine optional major liquors and three bottles of minor ingredients such as dry vermouth, sweet vermouth, and lemon mix. When a drink key on the control register is pressed, the proper major and minor ingredients are automatically dispensed in the exact portions required for that drink. If, however, the bourbon key is pressed, only bourbon is dispensed in either highball or cocktail portions. Movement of the liquor from the bottle racks to the dispensing head is done by compressed air.

The dispensing head is designed to be mounted under an existing bar and in proximity to the control register. A guide helps center the glass under the pouring head and a safety switch prevents dispensing of liquor unless the glass is correctly positioned. The dispensing head features 12 separate pouring lines, one for each bottle, to avoid contaminating the liquor or intermixing any of the ingredients.

The compressor furnishes the compressed air necessary to move the liquor from the bottle racks to the dispensing head. The air from the compressor is filtered to ensure that it is free of contaminents. It has its own power source so that it can be operated either in the immediate bar environment or in a remote location.

This new electronic bar system performs the following six functions in only one and three-fourths seconds: (1) dispenses the drink in the exact portion and recipe for the key pressed; (2) updates the liquor inventory; (3) records and indicates the correct price; (4) accumulates accounting control information; (5) prints a journal record for audit purposes; and (6) prints on a guest check, when required. The result is better control for the bar owner and faster service for the customer. ▲

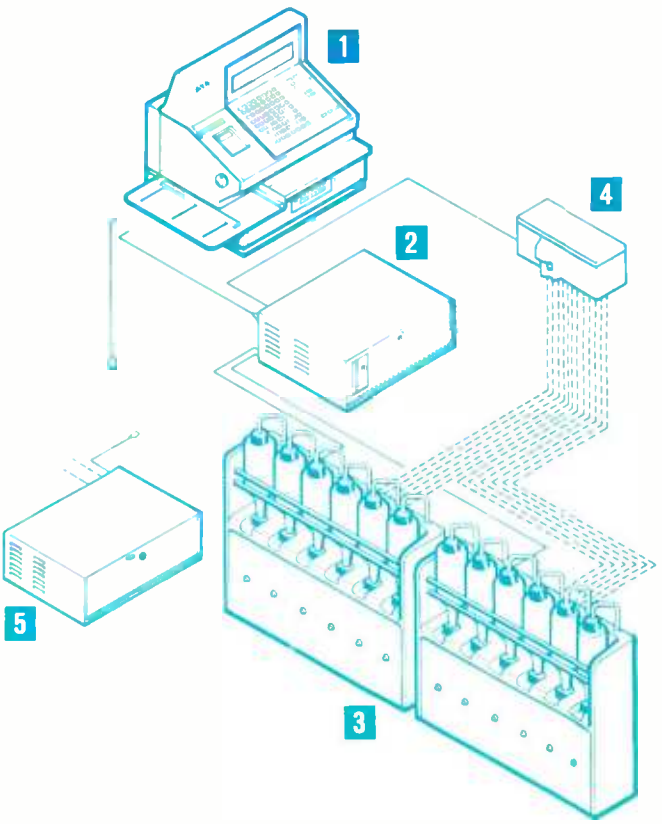
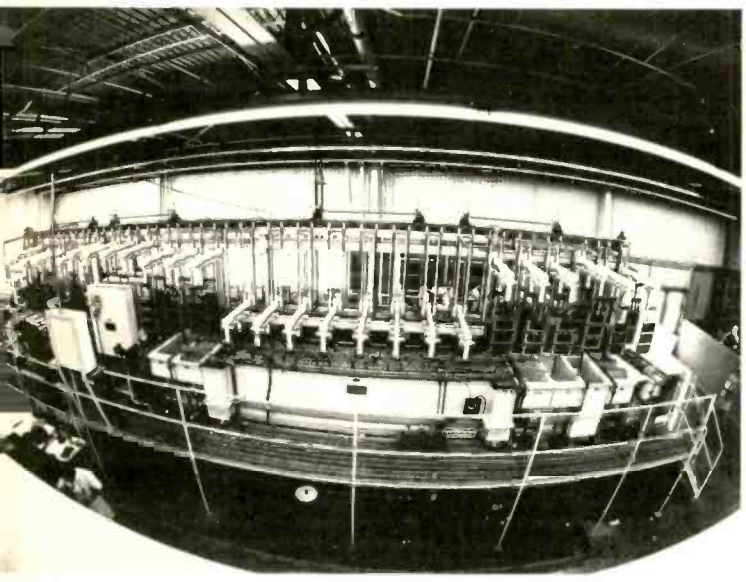


Fig. 1. The automatic bartender is composed of five units: (1) the control register, (2) the logic unit, (3) the liquor-bottle racks, (4) drink-dispensing head, and (5) compressor.

Electronic bartender accommodates 12 bottles of liquor.

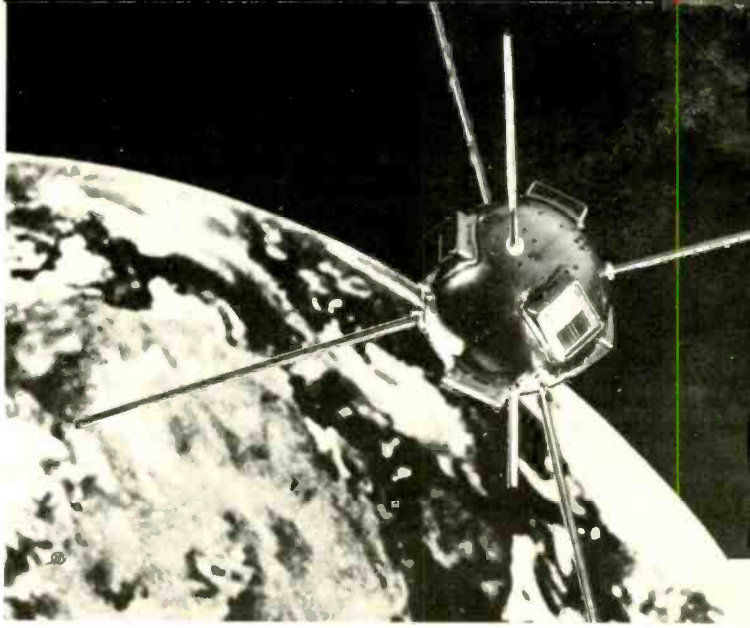


Recent Developments in Electronics

Digital System Reduces Map-Making Time. (Top left) An experimental system for dramatically reducing the time involved in color map making is being developed by IBM for U.S. Army Engineer Topographic Laboratories. The system uses an optical scanner/plotter, a computer, and a display unit to produce separation negatives for the maps. Engraving time is reduced from months to as little as one day. First, the optical scanner converts colored-pencil line drawings into binary information. After scanning, computer programs search the data, follow the lines, and store the image in computer memory. Then the computer, acting in the role of an "engraver," puts together an image composed of microscopic spots, as commanded by the recognized colored-pencil codes. Highways, railroads, and lakes are "drawn" by the computer much in the manner of laying microscopic square floor tiles. Film transparencies are created, each with millions of these square spots, on the optical scanner/plotter. These transparencies in turn are used for making the lithographic plates for the color printing process.

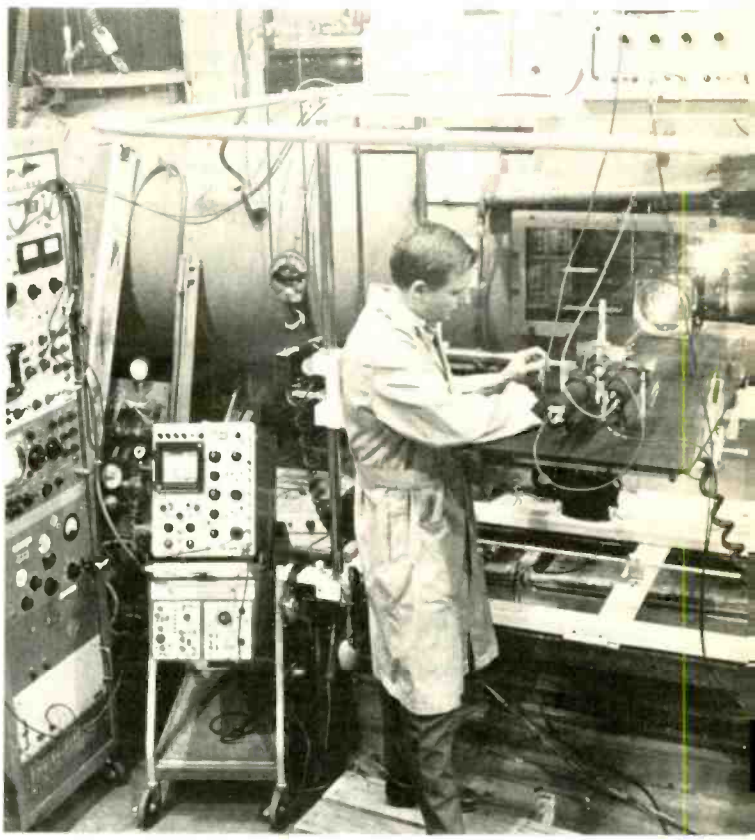
Fully Automated Plating Machine for PC Boards. (Center) A fully automated plating machine now operating at The Singer Co.'s Friden Div. is realizing savings of 50 to 75 percent in plating printed-circuit boards. The machine, made by Meaker Equipment, is 48½-feet long by 9½-feet wide by 19¼-feet high. Potential capacity of the unit, based on two-shift operation, is one million PC boards a year. Each of the machine's 56 carrier arms accommodates two racks of different sizes of PC boards. Each rack holds one to four boards, so the fully loaded machine may be handling close to 450 boards at any one time. There are 17 tanks used for the automatic copper and tin-nickel plating. The copper plating tank has a capacity of 2600 gallons of copper pyrophosphate bath and occupies one full side of the machine. Portions of this tank are operated at a current density of 5 amperes per square foot; other portions at 20 amperes per square foot. The 56 carrier arms are chain-driven around the machine and raised or lowered automatically at the individual stations.

Robots on the Assembly Line. (Below left) A portion of the highly automated assembly line used to put together the new, little Chevrolet Vega is shown here. The "robots" alongside the line are actually 5-axis industrial manipulators (Unimates) that are equipped with specially designed lightweight portable welding guns. An operator uses a "teach cable" to initially move the welding gun through its desired cycle. The Unimate memorizes the exact location of its tool and the series of motions required to move it there. The unit then accurately repeats that pattern of tool movements—time after time. Along each side of the line, 11 robots and one automatic welder complete body welds with a consistent accuracy of $\frac{1}{16}$ inch. Although they are capable of making up to 60 spot welds, time limitations restrict each unit to a maximum of about 20. The car-assembly plant employs a total of 26 manipulators, with two spare units as emergency replacements, as well as 49 other automatic welding devices for the Vega body. We hope the new units will do a better job than some of the sloppy welds we have seen on some of the new cars.



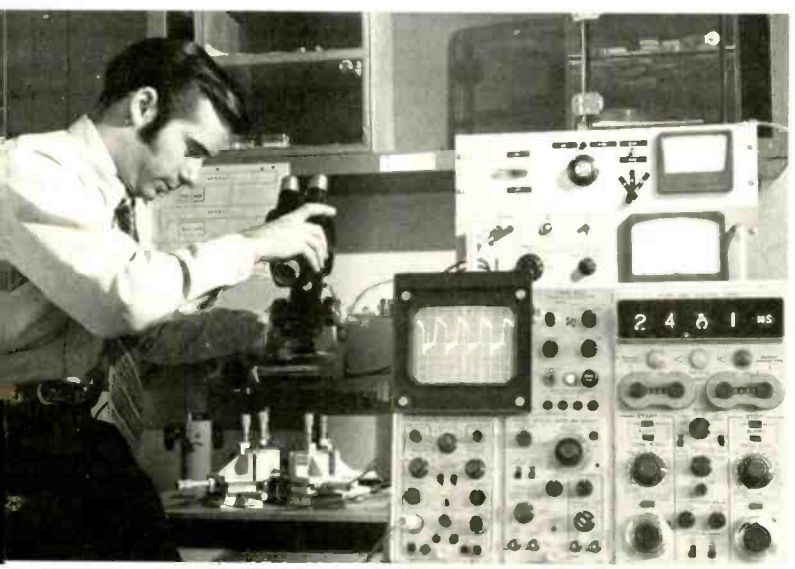
Vanguard Celebrates Thirteenth Birthday. (Top right) Remember Vanguard I? Yes, it's still orbiting around the earth along with lots of other space "junk," even though it was launched over 13 years ago. The satellite was launched on March 17, 1958 and has provided a wealth of information on the size and shape of the earth, which was found to be slightly pear-shaped rather than perfectly round. Although it was preceded in space by two Soviet Sputniks and the U.S. Explorer I satellite, none of these other space vehicles is still in orbit. The 3-lb, grapefruit-sized Naval Research Laboratory satellite was the first orbiting package to be powered by solar energy. Although the solar batteries failed in 1964 and the satellite's speed has slowed very slightly, it is still being tracked. Scientists say it will remain in orbit for as long as 2000 years.

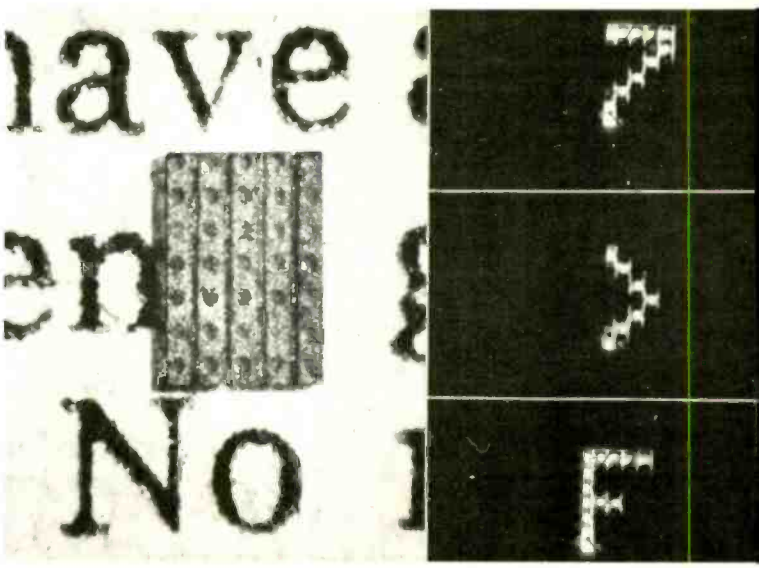
Laser Velocimeter Measures Airflows. (Center) A 500-mW argon laser is being used by the U.S. Air Force's Arnold Engineering Development Center to measure the velocity of airflows in wind tunnels. Prior to the use of this particular laser arrangement, it was necessary to "seed" the airflow with particles of material which could be detected. These added particles did not always travel at the same speed as the airflow; hence, velocity measurements were incorrect. With the present setup, the laser velocimeter detects the naturally occurring particles in the airflow and is able to achieve accuracies of 99.5 percent and higher.



Sub-Nanosecond Silicon-on-Sapphire Switching Circuits. (Below left) A silicon-on-sapphire circuit is being tested here that is able to switch in less than a nanosecond (billionth of a second). The scope shows a waveform from a silicon-gate CMOS/SOS (complementary symmetry metal-oxide semiconductor/silicon on sapphire) 25-stage ring oscillator. The digital readout shows that the 50 "on-off" switching delays required per cycle take less than 25 ns, or less than 0.5 ns per delay. The devices operate as fast as emitter-coupled bipolar transistor gates yet dissipate only one-millionth of the standby power consumed by the bipolar circuits. The circuits are under development by RCA for the Air Force Avionics Laboratory.

Miniature Light-Emitting Diode Arrays. (Below right) A new and simplified process for making complex display panels from thousands of tiny light-emitting diodes, each no larger than a grain of salt, has been announced by GE scientists. The process permits thousands of the diodes, each producing a dot of light, to be controlled with a minimum of interconnections and external wires. To form a single letter, number, or symbol in a display panel, 35 of the diodes are combined in a rectangular 7 by 5 element array. At the left a typical array is shown on a bit of newspaper print. By activating the diodes in various combinations, as at the right, the array can produce all the standard computer characters.





Solid-State Band-Switching Circuits

By WILLIAM G. WHEELER/Design Engineer, Heath Company

How diodes and transistors can be employed for receiver channel-and band-switching and to facilitate remote control.

THERE is an almost endless variety of diode and transistor switches. This article describes how some of these switches have successfully solved some problems in receiver design.

First, a few thoughts about diodes when used as switches. The effective impedance of the diode can be approximated by Ohm's law at frequencies below 30 MHz; impedance is the voltage across the diode divided by the current through it. For a given amount of current through the diode, a germanium diode will yield a much lower impedance than a silicon, but this impedance will change greatly due to temperature. Because of this lack of temperature stability, it is frequently desirable to use a silicon diode and design the circuit to "live with" the higher impedance in the "on" state.

Another item to consider is the capacitance across the diode junction when the diode is in the "off" state. As the operating frequency of the circuit increases, the more disadvantageous this leakage capacitance becomes. This can be overcome by using any of a number of low-cost computer diodes which have low capacitance.

Care must be taken to insure more bias current than the peak anticipated signal current so that the diode will not be switched off during a portion of the signal cycle.

Solid-State Band Switching

Recently the author was involved in the design of a seven-channel, crystal-controlled, two-band v.h.f. receiver. It was decided to do all channel- and band-switching with solid-state techniques to facilitate remote control.

Because of the relationship of the two bands and the v.h.f. frequencies involved, efforts to switch coils and capacitors proved unsuccessful, so it was decided to use two separate front-ends and two oscillator-tripler strings. This generated the need for crystal switches, oscillator band switch, i.f. input band switch, antenna band switch, and a scheme to run the band switches from the channel selector.

These various switches are shown in Figs. 1 through 4. (In all circuits, C_E should have a capacitive reactance of from 1 to 5 ohms.) The two band-switch lines are driven by the circuit of Fig. 4 so that the desired one is one diode drop above ground while the other is close to the supply potential due to a number of leakage paths (mostly transistor bias resistors).

Design targets for this receiver required low current drain, consequently diode currents fulfill more than one function. For example, in Fig. 1A, the bias resistors for the "on" (conducting)

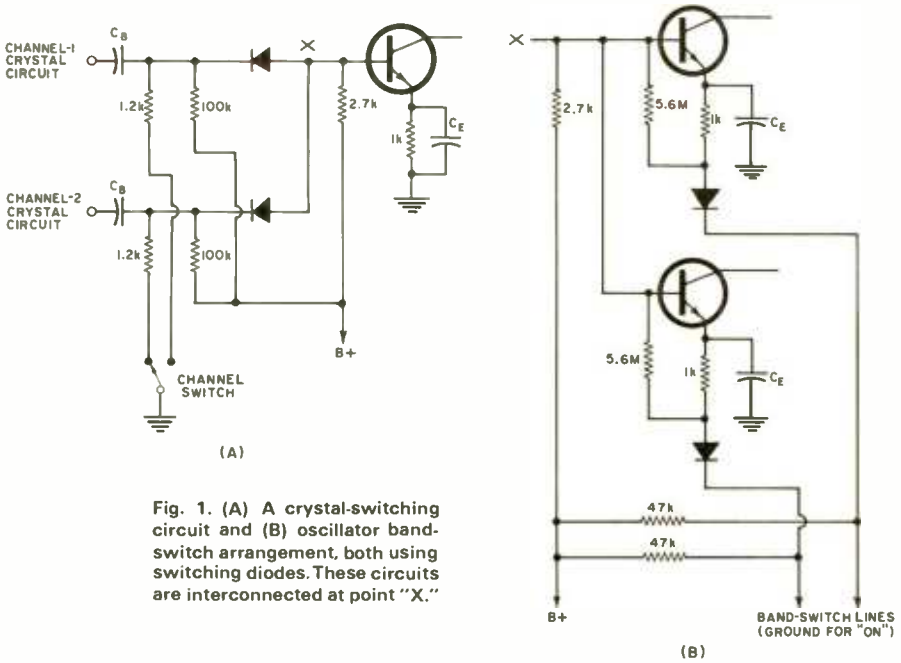


Fig. 1. (A) A crystal-switching circuit and (B) oscillator band-switch arrangement, both using switching diodes. These circuits are interconnected at point "X."

diode also act as the bias resistors for the transistors; in Fig. 1B, the forward-bias current for the "on" diode is the emitter current for the transistor being used.

C_B in Fig. 1A is the coupling capacitor to the crystal circuit; the capacitor also acts to block the d.c. voltage from the diode bias circuit. The 1200- and 2700-ohm resistors are adjusted to provide the proper bias for the transistor in conjunction with the 1000-ohm emitter resistor. The 100k-ohm resistors are used only to supply reverse bias to the "off" diode so their resistance can be any value up to about 10% of the diode's reverse resistance.

The circuit in Fig. 1B connects to that of Fig. 1A at point "X." Here, again, the 47k-ohm resistors are used only to supply reverse bias to the diodes, so they can be any value up to 10% of the diode's reverse resistance. The 5.6-megohm resistors are used to apply the transistor's base voltage to the emitter of the transistor and to the anode of the diode. These serve the dual purpose of protecting the transistor's base-emitter junction from reverse breakdown and applying a low voltage to the anode of the diode to insure that it is reverse-biased.

The circuit of Fig. 2 was used at the i.f. input instead of the simpler Fig. 1A circuit because of the possibility of a large signal at the mixer output. This circuit uses the full drain current of the mixer to forward-bias the switch. This switch is turned on by using the small amount of current available from the "off" band-switch line to supply base current for the transistor.

When the left band-switch line is grounded and the right is ungrounded, mixer 1 is operative as follows: "B+" is applied to the base of the switch transistor through the 27k- and 10k-ohm resistors, turning this transistor "on." This permits current to flow through the transistor and diode from the drain of the mixer so it can function. At the same time the base of mixer-2 switch transistor is at ground potential which turns it off. Also, this ground potential is passed to the anode of the mixer-2 diode which back-biases it and turns it "off," since its cathode is close to "B+" due to leakage through the mixer drain and source. The diode supplies low-leakage capacitance through the "off" switch.

The 100k-ohm resistors can be a high value since they are used only to back-bias the diode. The 10k-ohm resistors should be at least this value to keep from loading the signal line and should not be much bigger so the voltage drop caused by base-current flow will not be excessive. The 27k-ohm resistors should not be so large that base-current flow causes significant voltage drop and should not be so small that appreciable power is wasted when the band-switch line is grounded.

In Fig. 3 the bias current can be low because, although large signals may appear on the antenna, only a small portion of this signal will appear at the forward-biased diode because its impedance is transformed to a high level at the junction of the two coax lines by the quarter-wave section.

When one band-switch line is grounded, current flows from the "B+" supply through the 2200-ohm resistor, the diode, and the 1000-ohm resistor to ground. This causes the diode to have a low impedance, thereby connecting the bypass capacitor to the antenna line. This low-impedance shunt on the line is transformed back to the coax junction through the quarter-wave line to be a high impedance. As a result, practically no signal current follows this path. At the same time, "B+" is applied to the cathode of the other (lower) diode while one half of "B+" is applied to the anode through the 2200-ohm resistor. This gives the lower diode a very high impedance so it is effectively out of the circuit and the 50-ohm transmission line is left connecting the antenna to the desired front-end. The 1000- and 2200-ohm resistors are selected to allow the greatest possible current to flow through the forward-biased diode yet not load the signal line. These resistors also supply half of the "B+" voltage to the anode of the back-biased diode so only the very strongest of incoming signals will be clipped.

The circuit of Fig. 4 is constructed with a wire on the anode of each diode which may be connected to either of the two band-switch lines. Hence, any channel-switch position can be used for either a high- or low-band channel and may be changed easily when the crystal is changed. ▲

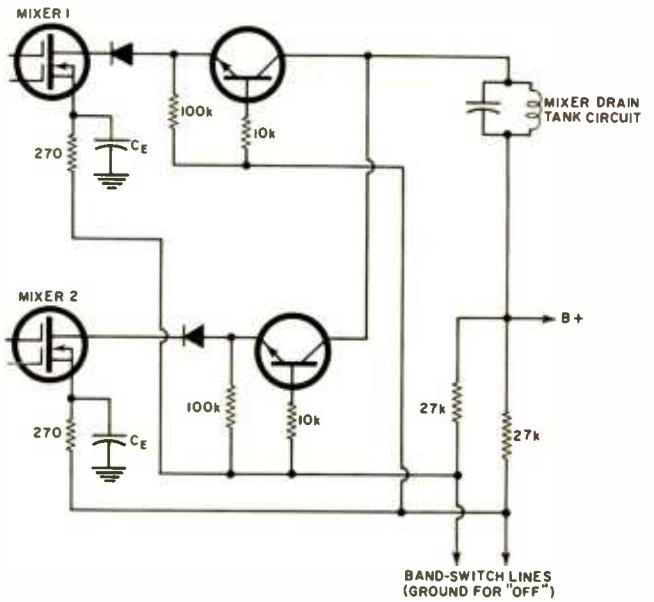


Fig. 2. The i.f. input band-switching arrangement.

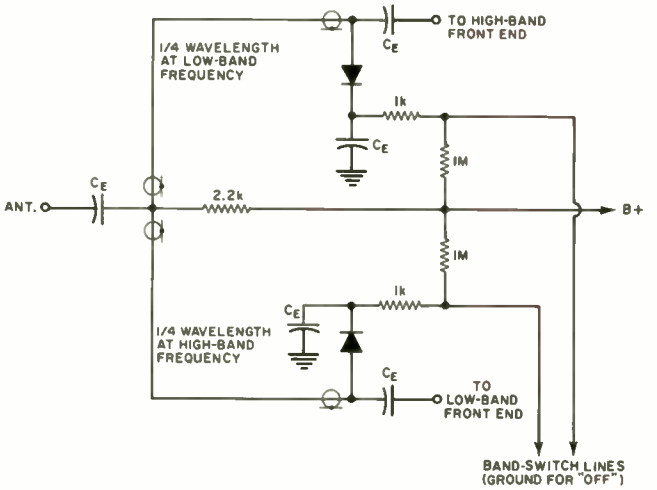
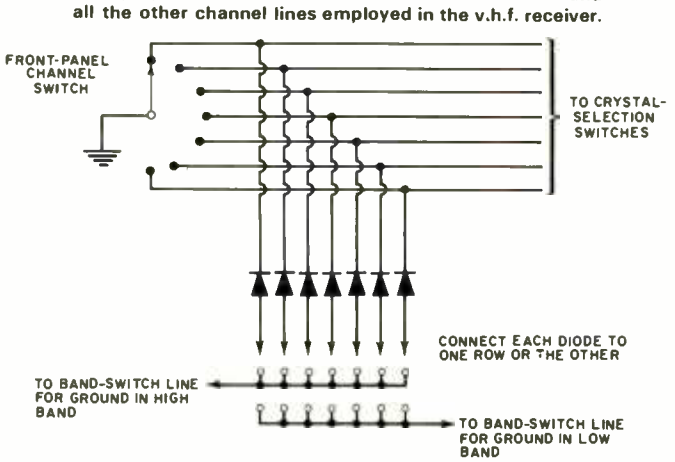


Fig. 3. Diode switching that was used in antenna circuit.

Fig. 4. Band switch to channel-switch interconnections. This circuit permits the ground from the selected channel-switch line to be conveyed to the desired band-switch line with proper isolation from the other band-switch line and all the other channel lines employed in the v.h.f. receiver.



Calibrating Digital Voltmeters

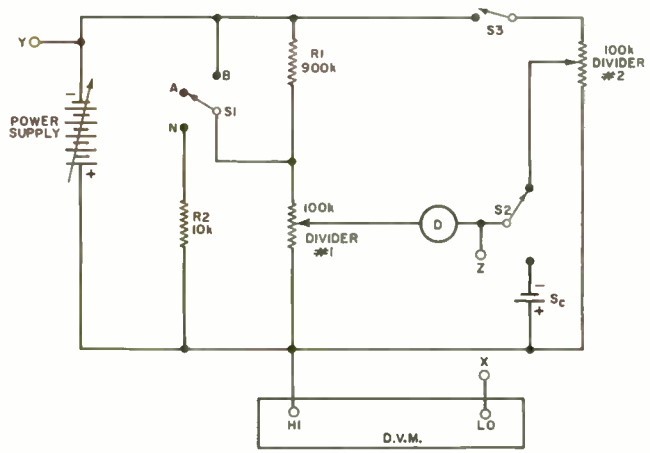
By M/Sgt. DAVID L. KIERSTEAD
Air Force Metrology Training Program, Lowry AFB, Colorado

Method employed at a precision laboratory to calibrate and check the accuracy of a d.v.m.

FOR state-of-the-art accuracy in metrology, a 10:1 ratio must be maintained. When a standard's accuracy does not meet or exceed a 10:1 ratio to the accuracy of the instrument being calibrated, a record of the true ratio should be noted. Many digital voltmeters now in use have a manufacturer's stated accuracy of ±25 parts per million (ppm). This creates problems in many laboratories trying to maintain the required 10:1 ratio, since working standards are usually accurate only within ±5 ppm, or a 5:1 ratio. A constant search for more accurate methods of measurement and more precise standards should be the mutual goal of manufacturer and user.

Fig. 1 shows the equipment used and the means of adapting it to various configurations for calibrating all ranges of a digital voltmeter (d.v.m.).

Fig. 1. Test setup used to calibrate digital voltmeter.



Divider #1 is a seven-decade Kelvin-Varley divider with an input impedance of 100k ohms and a terminal linearity of 0.1 ppm. Divider #2 is a five-decade unit with an internal impedance of 100k ohms and of any accuracy. $R1$ (900k ohms) and $R2$ (10k ohms) are standards with short-term stability of better than 1 ppm. The null detector (D) is an electronic detector with a variable sensitivity to one microvolt full-scale. The power supply is a stable seven-digit source with a manufacturer's stated accuracy of 100 ppm. Its output can be maintained at the accuracy given the standard cell (S_c) by connecting switch $S2$ to the standard cell and adjusting the power supply.

The voltage standard is a saturated standard cell in a hermetically sealed oven kept at a temperature of 35° C. The cell used for this procedure has a value of 1.017586 volts, ±5 microvolts. Switch $S1$ is used to extend the range of divider #1 for application up to 1000 volts. The addition of $R1$ and $R2$ eliminates loss of resolution in divider #1. Switch $S2$ is used to monitor the output of the power supply relative to the standard cell or to connect divider #2's output to the detector.

The d.v.m. to be calibrated was a potentiometric, continuous-balance type. It has an adjustable internal power supply, an internal voltage divider, and three range resistors (for 10, 100, and 1000 V).

Calibration Procedure

To start the calibration process, place switch $S1$ in position B, switch $S2$ to the standard cell, and close switch $S3$,

(Continued on page 62)

AIR FORCE METROLOGY TRAINING PROGRAM

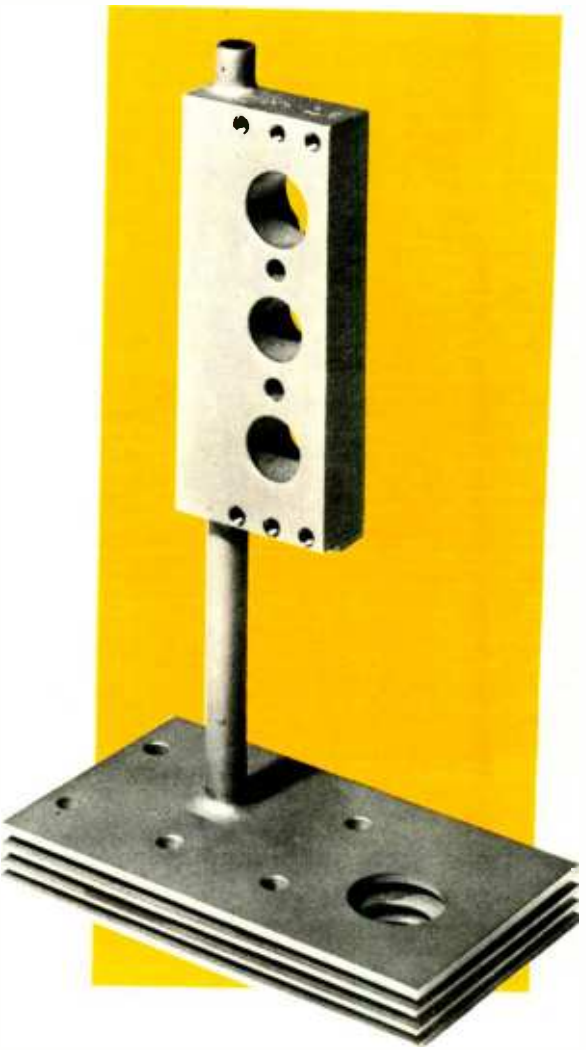
The Air Force metrology training program is conducted at Lowry Air Force Base, Colorado. Its goal is the development of responsible, knowledgeable airmen capable of high performance. Airmen are admitted to the program only after extensive aptitude testing and personal interviews. Important facets in achieving the program goals are: careful evaluation of the curriculum, and the performance and attitude of the instructor in the classroom. The curriculum is constantly revised or updated to maintain credibility as newer and more sophisticated equipment is introduced. The general objectives of this training program are that each student:

1. Will be able to use calibration standards at a level established by the National Bureau of Standards.
2. Will be knowledgeable in the principles of electronics.
3. Will be able to analyze and isolate malfunctions and calibrate and certify precision measuring equipment.
4. Will be fully aware of his responsibility in maintaining the high state-of-the-art in metrology.

Heat Pipes for Semiconductor Cooling

by DAVID L. HEISERMAN

More efficient than conventional heat sinks for cooling semiconductors, these heat pipes carry heat as a fiber-optic "pipe" carries light.



This assembly uses a heat pipe to cool three transistors, which are attached to the rectangular copper block through the three large holes. Heat is carried through a ¼-in diameter heat pipe to four cooling fins. Assembly is manufactured by RCA for Avco Electronics for use in C5A aircraft.

A HEAT pipe is a tube-like structure that treats heat energy in much the same way a fiber-optic "light pipe" treats light energy. The heat pipe passes heat energy smoothly and evenly from one end of itself to the other with virtually no regard for over-all length, twists and bends, and conditions of the outside environment. Ordinary metal heat conductors cannot perform such a feat.

Perhaps the most obvious electronic application of heat pipes is that of cooling power semiconductors—especially those confined to close quarters. The output transistors in a satellite communications system, for instance, must be cooled in such a way that their heat doesn't affect the other components around them. Conventional heat sinks add passive weight, take up valuable space, and put some severe restriction upon the satellite's component layout. A heat pipe connected to the power semiconductors, however, can lead the excess heat energy around other heat-sensitive components and through other sections of the satellite to a massive part of the metal framework. This technique eliminates all the disadvantages of heat sinks and does a better job of cooling the semiconductors.

How They Work

Modern heat pipes work according to two old and familiar principles of physics. One principle, heat transfer by evaporation, is responsible for making a material covered with an evaporating fluid feel cool to the touch. The other, capillary action, is responsible for making a fiber wick draw fluids up out of a container.

The first heat pipes, those developed in the early 1940's, took advan-

This 250-ampere rectifier uses a combination of a ceramic heat pipe and cooling fins to keep the silicon wafer no more than 10 degrees C warmer than fins. Without the heat pipe, temperature difference would be in excess of 70 degrees C.

edge of only the first principle—heat transfer by evaporation. These heat pipes were simply sealed metal pipes that contained a bit of volatile fluid. Heating the fluid at one end of the pipe set up an evaporation process that soon filled the pipe with warm vapors. Wherever the vapors touched the cooler sides of the pipe, they condensed. Since the temperature of evaporation and condensation are always the same, the temperature of the pipe soon became very nearly the same at every point. This is still one of the really unique properties of heat pipes.

These first heat pipes, however, maintained an even temperature distribution only as long as some fluid remained in the heated end of the pipe. Once the fluid in the heated end dried up, that end of the pipe became much hotter than the other end; and, from then on, the heat pipe behaved like an ordinary metal heat conductor.

Early heat-pipe researchers recognized the need for setting up a complete heat-pipe cycle—one that included a step for returning the condensed fluid to the heat-input end. One result of their work was a heat pipe that had to be operated in a vertical position so that gravity could return condensed fluids to the heated bottom end. Another attempt at completing the heat-pipe cycle involved an external mechanical pump to recirculate the fluid. Neither of these solutions, however, proved to be satisfactory. The gravity solution seriously limited the heat pipe's usefulness to a small range of applications in stationary equipment, and the pump solution increased size and complexity of the system.

In the late 1960's, G. Yale Eastman and his research group at *RCA* set out to develop a whole new technique for completing the heat-pipe cycle—one that relied neither upon gravity nor external moving parts. Their final answer to this problem involved the application of the second principle of physics already mentioned—capillary action. *RCA* heat pipes now have a capillary structure lining the inside surfaces. Most of these capillary structures are fiber wicks made of materials such as fiber glass. A few experimental heat pipes, however, use capillary structures made of porous metallic compounds or have hundreds of fine longitudinal grooves milled along their inside surfaces. Regardless of the actual form, the capillary structure acts as a "capillary pump" to return condensed working fluid to the heat-input end of the pipe (Fig. 1).

These heat pipes, then, are relatively simple devices that operate in any position without the aid of any mechanical moving parts. Some heat pipes are so simple, in fact, the heat-input (evaporator) end and heat-output (condenser) end are interchangeable.

Special Properties and Applications

Modern heat pipes have four special properties that are already responsible for some simple and inexpensive solutions to problems that have plagued engineers for decades. These special properties are: (1) high thermal transfer capacity, (2) even temperature distribution, (3) high thermal "inertia," and (4) thermal isolation.

It is possible to construct heat pipes that have thermal-transfer capacities thousands of times better than the best passive heat-transfer devices. The main reason for this tremendous difference lies in the fact that the rate of heat transfer by fluid evaporation is always much greater than it is for metallic heat conduction. A practical comparison shows that a heat pipe can do the job of an extruded aluminum heat sink that is between two and ten times larger.

The second special property of heat pipes is their ability to distribute heat evenly over their entire surface area. This property, sometimes called "temperature flattening," comes from the fact that the evaporation and condensation temperatures are exactly the same as the temperature of the vapors that fill the pipe. Researchers can warm a heat pipe with a highly nonuniform flame, and measure only very tiny temperature differences between any two points on the pipe's surface. By way of comparison, aluminum heat sinks used in conjunction with power semiconductors tend to be much hotter around the semiconductor than anywhere else.

The third special property of heat pipes, thermal inertia, tends to hold the envelope temperature constant in spite of fluctuations in the amount of heat input. Although a heat pipe can do this job quite well by itself, connecting a heat sink to the condenser end raises the pipe's thermal inertia incredibly high. As an example, a series of experiments with a heat-pipe heat-sink combination showed that ten-fold fluctuations in input heat changed the envelope temperature by less than one percent.

The temperature flattening effects and high thermal inertia of heat pipes can lead to applications other than those dealing with heat transfer. It is possible, for instance, to construct a simple, lightweight, and inexpensive electronic-component oven that displays an unusually high degree of temperature control and uniformity. By surrounding the components with a heat pipe that is warmed with ordinary electric heating coils at the evaporator end, every component takes on exactly the same temperature. Furthermore, the heat pipe's thermal inertia is so great that it is sometimes possible to eliminate the heating coils and operate the component oven with excess heat from power semiconductors elsewhere in the system.

The fourth property of heat pipes is that of thermal isolation. The main thermal connection between devices at either end of a heat pipe is a vaporized fluid, and this means that the size and kind of heat source has little bearing upon the kind of heat dissipator, if any, connected to the condenser end. Perhaps the most remarkable single advantage of heat-pipe thermal isolation is that it completely elimi-

nates the awkward problems often involved in matching the thermal impedance of a heat source material to that of its heat dissipator. Mismatches in the thermal impedance of a power semiconductor and its passive heat sink, for example, can make the cooling system highly inefficient.

RCA, under an Army R&D contract, developed a special 250-ampere silicon rectifier assembly that uses a ceramic heat pipe to carry thermal energy away from the silicon wafer to external aluminum cooling fins. Without the heat pipe, thermal impedance mismatches among the silicon, a metallic case, and the aluminum heat sink would let the wafer run about 70° C hotter than the other materials. Using the ceramic heat pipe as both a case and a thermal impedance-matching device, however, the wafer runs only about 10° C warmer than the cooling fins.

Design Limitations

A device as unique as a heat pipe is bound to have a few unique design limitations. In the case of a heat pipe, the design limitations are: (1) maximum heat transfer, (2) maximum and minimum operating temperature, and (3) maximum heat density.

The superb heat-transfer characteristics of a heat pipe break down whenever the input power outruns the ability of the heat pipe fluid cycle to keep up. The heat-transfer capability of a heat pipe is, for the most part, a function of the pumping capacity of the capillary structure and the viscosity of the working fluid. Designing a heat pipe with a very high heat-transfer specification is a matter of selecting a capillary structure that has a high pumping capacity and a working fluid that has a low viscosity.

The maximum operating temperature of a heat pipe depends upon the boiling point of the working fluid and the ability of the envelope to contain high vapor pressures. At its optimum operating temperature, the working fluid in a heat pipe evaporates quite readily, but doesn't boil. It is possible to operate a heat pipe at the boiling temperature of the working fluid, however, providing the walls of the envelope can withstand the pressure.

The minimum operating temperature reflects the temperature at which the working fluid no longer evaporates rapidly enough to maintain an even temperature distribution along the entire length of the heat pipe. Heat pipes designed for electronic heat-transfer applications generally use working fluids that begin to evaporate at temperatures slightly above ordinary room temperature.

A maximum allowable heat density is the third major design limitation for heat pipes. This rating, expressed in watts per square centimeter, indicates the maximum rate of heat input per unit area of heat pipe. Exceeding a heat pipe's maximum heat-density rating can buckle the pipe or even melt a hole through it.

Like the maximum operating temperature rating, the heat-density limit is closely tied to fluid boiling phenomena. Any kind of fluid actually boils in one of two different ways, depending upon the rate of heat input. At "low flame," for example, a pot of boiling water contains thousands of tiny vapor bubbles that rapidly rise to the surface and burst. Increasing the rate of heat input with a "high flame" doesn't increase the temperature of the boiling fluid, but it does change the nature of the boiling. Increasing the rate of heat input changes the tiny gas bubbles into large pockets of vapor that are covered with a thin film of fluid. In the vocabulary of the kitchen, this is a "rolling boil," but the proper laboratory term is "film boiling."

The maximum heat-density rating for a heat pipe indicates the point at which vigorous film boiling begins. Whenever film boiling occurs in a heat pipe, the layer of fluid film keeps the hot vapors concentrated into a relatively small area until the bubble bursts. Unfortunately, these pockets of film-covered hot vapors always appear at the point of high heat input. This combination of confined hot vapors and high input temperatures upsets the pipe's temperature flattening characteristic and thus creates hot spots.

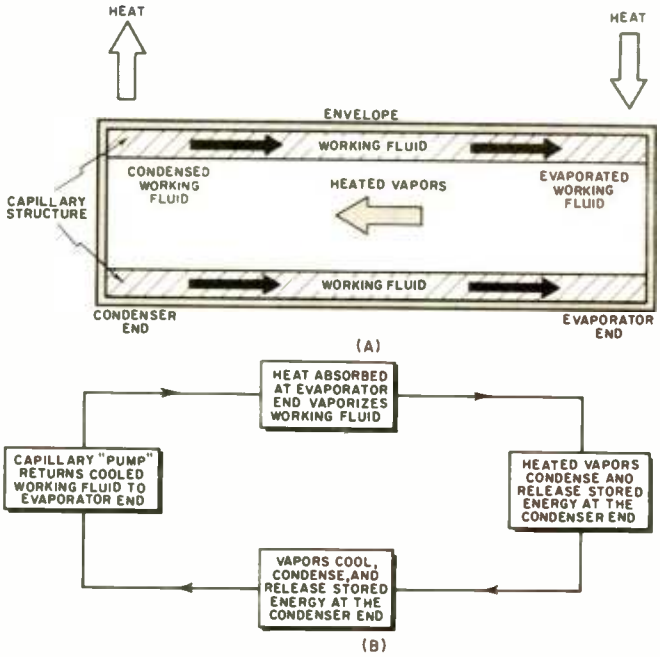


Fig. 1. (A) Heat-pipe cross-section and (B) operating cycle.

The three main design limitations of heat pipes are just limitations, and not real disadvantages that must be overcome. As long as engineers use the devices within the design limits, the only real present-day disadvantages of heat pipes are their relatively high cost and short supply—both economic, and not technical, stumbling blocks. ▲

Summary of experimental heat-pipe material and ratings. Materials listed in the working fluids column which are normally solid at room temperature, such as lead for example, are assumed to be in a molten form in this particular application.

MATERIALS		
Envelopes	**Working Fluids**	**Capillary Structures**
ceramic	acetone	fiber glass
copper	bismuth	finely machined longitudinal slots
glass	cesium	porous metallic compounds
molybdenum	fluoridated hydrocarbons	
nickel	indium	
stainless steel	inorganic salts	
tantalum	lead	
tungsten	lithium	
alloys and combinations of the above	mercury	
	methanol	
	potassium	
	water	

RATINGS	
Operating Temperature Ranges	Less than 0°C to 1980°C
Power Ratings	2 watts to 17 kW
Dimensions	¼ inch to 6 inches in dia. 3 inches to 3 feet long

◀ The technician uses a whole battery of TV test equipment for making the waveform photos that are then used in TV service manuals.

Vocation

The TV

A JACK of many trades. That's what a technician is when working in the Product-Service group of a television manufacturer such as *General Electric.* Not surprisingly, therefore, the duties of these technicians bring unique and challenging experiences and opportunities.

Two of the many important functions of the Product-Service group are: 1. preparing technical service literature, and 2. improving field-service techniques.

Typical responsibilities of these technicians include:

- Troubleshoot and repair TV receivers being field-tested.
- Perform tests and measurements on TV receivers to obtain information for service literature and technical-training material.
- Work with field-service and engineering departments on TV receiver serviceability.
- Follow up production changes and field problems.

The first responsibility listed involves TV receivers returned from the field after special engineering evaluation, as well as production and prototype receivers. In this area of troubleshooting, one of the qualifications for the job is prior experience in general TV service work.

Other responsibilities require knowledge of advanced electronics and TV theory, design, troubleshooting techniques, and the ability to prepare technical service notes.

Product-Service technicians help to prepare a service manual through six basic assignments, all of which are done under the direction of a training specialist who is responsible for over-all preparation of the service manual.

These assignments are:

1. *Voltage and waveform measurements.* Working with a schematic and production receivers, a technician takes voltage and waveform measurements for the service manual. For accurate average readings, many receivers may be tested, with both v.t.v.m. and v.o.m. measurements. Waveform photographs are made at key points. Along with other artwork and composition, the photos are incorporated into the service manual by publication specialists.

2. *Disassembly/assembly instructions.* With a new chassis on his bench, a technician is the first in Product-Service to disassemble this receiver. In so doing, he writes the step-by-step disassembly instructions. Since the technician has prior experience in general TV service work, he understands how important it is for a service manual to have all necessary information.

3. *Adjustment and alignment procedures.* After the training specialist has written instructions for adjustment and alignment, he has a technician follow the procedures. In this way, the technician puts the procedures to a practical test. As with the disassembly instructions, the technician is representing the entire servicing profession when he checks out this service-manual information. These procedures must be easily understood and must work with the average TV service technician's equipment. Areas covered include verifying proper bias, identifying test points, and determining test-equipment loading effects.

4. *Troubleshooting procedures.* These are developed from the technician's own observations and from ideas reported by television service technicians. When a useful troubleshooting technique is developed, it is generally communicated to selected field-service technicians for evaluation. Then, as a follow-up, these techniques or service hints are published in the service manual or in the company's service newsletter. A technician may issue a service letter on his own after researching a problem and writing up the solution.

5. *Service manual artwork proofreading.* All artwork is done by technical illustrators in the Product-Service group. Because the technician is familiar with the TV chassis, he is called upon to help proofread schematics, wiring diagrams, and printed-circuit-board patterns. Especially important in this proofreading is a final check of all production changes. To get sufficient leadtime to prepare a service manual, the manual is begun with pilot-run (pre-production) receivers; consequently, it is necessary to continually update product-service literature with each engineering change.

6. *Technical theory comprehension.* A technician contributes to another Product-Service publication—the technical training manual. For each major chassis, the technician helps training specialists prepare a technical-training manual which is given to thousands of service technicians at company-sponsored training sessions.

Three important jobs for the technician which are related to field service are: 1. field problems, 2. circuit modifications, and 3. serviceability.

Field Problems: A continuous effort is made in field problem follow-up. From service reports come case histories of certain prevalent or unusual component failures. With this reported data, a technician is able to simulate the trouble and help devise effective service procedures and techniques to overcome it.

Circuit Modifications: When a circuit modification is proposed, a technician helps to evaluate it. For instance, changing components or rewiring a printed-circuit board could pose a problem if not done carefully. By making the modification himself, the technician can anticipate possible problems and suggest precautions that might be helpful to those who'll be doing the work.

Serviceability: Of increasing importance to the service industry is serviceability. Although serviceability depends on TV designers, many suggestions for a more serviceable product are passed on to Engineering by Product-Service which, in turn, learns of the needs from the industry.

The company's Field-Service unit has prepared a service-

These television technicians prepare manufacturer's service data and help make servicing easier for other technicians in the field.

By RAYMOND E. HERZOG/ Supervisor, Service Parts
Product Service, General Electric Television Division

Profile:

Product-Service Technician

ability guideline checklist. Topics covered include: accessibility of components, time required to disassemble a chassis or sub-unit, product identification, and troubleshooting convenience.

As soon as a prototype of a new chassis is built, the Product-Service technician puts it through the serviceability checklist. For example, the time required to disassemble a high-voltage assembly or replace a power switch is measured with a stopwatch. The receiver's serviceability ratings are then compared with a standard and the results are evaluated by Engineering. Here they serve as a basis for design review.

Not all of these serviceability checks are performed by company personnel; representatives from both NEA and NATESA have also participated in such checks.

Work Environment & Qualifications

Product-Service technicians enjoy a diversified working relationship which provides an excellent understanding of the total operation from engineering design to field service, and from technical service-literature drafts, through publication, to finished service manuals.

Their work also brings them into contact with engineers—for technical information; factory foremen—for replacement components or resolving production problems; and television technicians throughout the nation—to provide up-to-date information on new models and service instructions.

The work area for technicians consists of a laboratory furnished with all necessary test equipment and photographic apparatus and stocked with replacement parts.

The test equipment has the accuracy needed to obtain reliable service-manual data; at the same time, it is not too different from that used by the average TV service shop, thereby closely simulating realistic service conditions.

This equipment includes: TV sweep generator, crystal-calibrated marker generator, crystal-controlled post-marker generator, marker adder, wide-band service oscilloscope, dual-trace triggered-sweep scope, color bar/dot/crosshatch generator, v.t.v.m., v.o.m., and an isolated variable autotransformer for the power line.

The photographic equipment, used to take waveform pictures and to photograph new TV models for the "User's Manual" consists of: a *Polaroid Land* camera, a 35-mm camera with close-up lens, tripod, and floodlights.

As might be expected, qualifications for these technicians are quite stringent but, basically, are much the same as for a top-notch TV service technician: namely, a thorough technical knowledge of television circuitry and troubleshooting experience. Technical education is necessary, such as an Associate of Applied Science, Electronic Engineering Technology. Hobbies like amateur radio are also helpful.

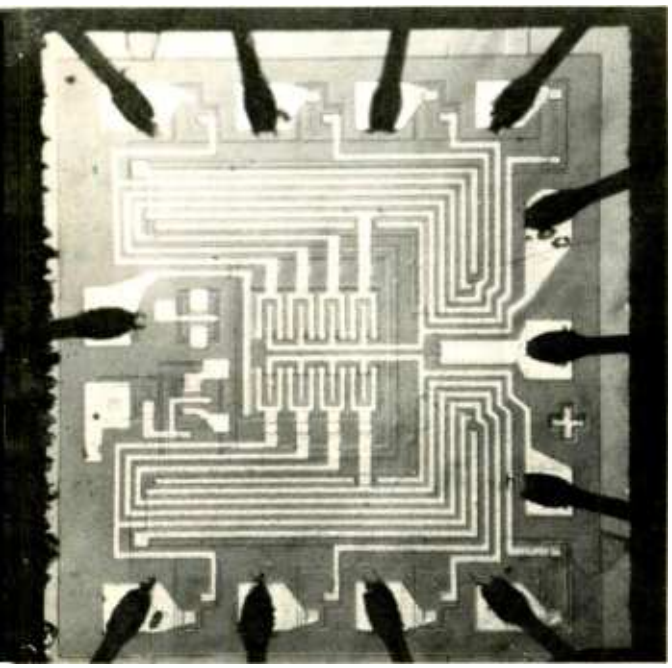
One *special qualification* is required: a good familiarity with the company's television receivers and their manufacture. This knowledge is best acquired from having worked as a technician at the company's TV plant. With a working knowledge of factory operations and plant layout and acquaintance with production foremen and materials personnel, Product-Service technicians find their jobs much easier in daily contacts with the factory.

A final qualification is a flair for writing and a talent for expressing ideas clearly. Since the objective of service and technical-training manuals is to convey information, it is helpful if the technicians are good writers.

The salary for a Product-Service technician is commensurate with his responsibilities and contributions to the company's business success. Progression from TV factory operations to Product-Service can continue to even more responsible positions. For example, a logical upward promotion would be to the post of training specialist, if he has a talent for writing and expressing ideas well. Or, should he become an expert in analyzing field-service situations, then a field-service specialist's job might be appropriate.

Also, his contacts with Engineering could lead to a transfer to the engineering product-development lab. Here, having previously worked with the finished product in Product-Service, the technician could then contribute his know-how to the development of even newer products. ▲

Author Ray Herzog (right) is using stopwatch to time technician Ira Kalfus in removing components from high-voltage cage of TV set. This is part of serviceability check used by manufacturer.



Photomicrograph of a typical CMOS structure—RCA's COSMOS gate CD4002, enlarged 150 times. See Fig. 4.

CMOS LOGIC: *Low Powered and Versatile*

By JOSEPH H. WUJEK, Jr.

Complementary metal oxide semiconductor IC's, in which both "n"-channel and "p"-channel MOSFET's are fabricated on a single die, offer new ways of obtaining very-low-power digital circuits.

SOME years ago, a tale which circulated in the electronics industry told of the woes of a designer of portable equipment. As the story goes, the engineer had designed the circuitry to a weight of three ounces but, unfortunately, the batteries to power the system weighed thirty-five pounds! This anecdote, while no doubt fictitious, nonetheless points up the need for very-low-power circuits. With the development over the last few years of complementary-metal-oxide-semiconductor (CMOS) integrated circuits, significant gains have been achieved in the important area of low-power digital circuits.

Before examining the CMOS structure and the inherent advantages in manufacturing processes and circuit performance, the notion of complementary devices is worth examining. Fig. 1 shows a complementary configuration of bipolar transistors such as might be used in the output stage of a digital circuit. When used in this manner, several desirable properties result. Because resistors are not used in the output, power dissipation is low when only one of the transistors is in the "On" (saturated switch) state, with the other "Off." This power dissipation in the "On" device is simply the collector current I_c, multiplied by the saturation voltage, $V_{CE(SAT)}$, plus the power dissipated in the base circuit ($I_B \times V_{BE}$), which is small (for high h_{FE} and good design practice) compared to the collector-emitter power. Apart from power drain due to leakage currents in the "Off" device, the only other power loss is in base resistors $R1$ or $R2$, depending upon which transistor is turned on.

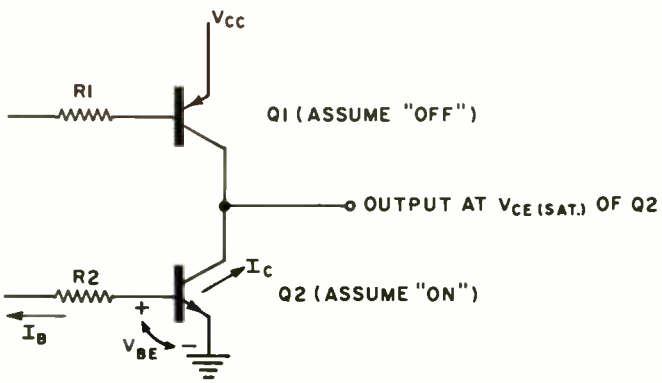
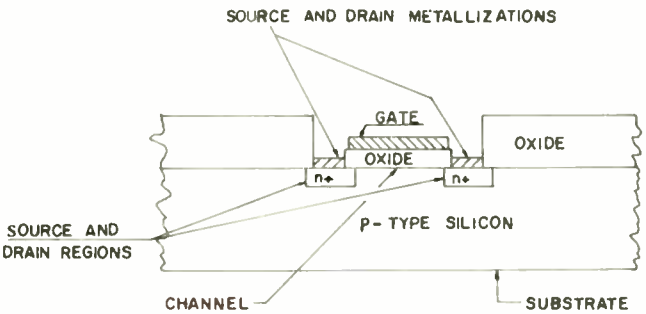


Fig. 1. Complementary configuration of bipolar transistors.

Fig. 2. Cross-sectional view of a typical "n"-channel MOSFET.



The above discussion considered a d.c. (standby) condition, that is, *either* of the transistors in saturation with the other off. During switching, there exists a time interval when *both* are conducting. This condition leads to a high current flow during a portion of either the rise or the fall of the output voltage. Hence, power dissipation is dependent upon the frequency of operation, as well as the transition times (rise and fall) of the output. These rise and fall times are in turn dependent upon the load presented to the output terminal, as well as the drive conditions and characteristics of the transistors.

Having thus examined the dynamics of a bipolar transistor complementary stage, a question arises: How can we further reduce power loss?

Since the bipolar transistor is current-operated, an answer to our problem would be a device which is voltage-actuated with a corresponding increase in impedance levels. Such a device is the field-effect transistor (FET) and, in particular one of the members of this category, the metal-oxide-semiconductor, or MOSFET.

Enter the MOS

In order to understand the operation of a MOS element, refer to Fig. 2 which shows a sectional view of such a device. The device depicted in Fig. 2 is an *n*-channel MOSFET, so called for reasons which will become clear when we examine the mechanism of conduction. For an *n*-channel device, a *p*-doped silicon crystal forms the substrate

with an oxide layer on top. The source and drain, consisting of *n*-doped silicon, is then diffused into a "well" or opening in the oxide layer. The source and drain, in a functional manner, correspond respectively to the emitter and collector of a bipolar transistor. Ultimately, the gate, source, and drain leads are formed by metallization over the oxide layer and *n*-wells. For *p*-channel devices, the starting substrate is *n*-type, with *p*-type drain and source.

When the drain terminal of an *n*-channel device is biased positive with respect to the source, and with no voltage on the gate, a very high resistance is measured between drain and source. In this "Off" state the resistance is on the order of 1000 megohms. Because no d.c. path exists between the gate and either the source or the drain, the input resistance of the gate to either source or drain is also very high, usually above 10^{12} ohms at room temperature. The absence of a d.c. path in the gate circuit also gives rise to the name "insulated gate" FET, or IGFET.

When a positive voltage (with respect to the substrate) is applied to the gate, electrons are "pulled" from the electron-rich *n*-regions and form a conducting *channel* of *n* material between source and drain. This equivalent "On" resistance between source and drain is in the range of from 1000 to a few thousand ohms. The gate, however, still "sees" no d.c. path; hence, a very high resistance appears between the gate terminal and either of the other two terminals. In fact, the *only* load which appears at the gate is the capacitance which must be charged, and is typically 3 to 5 picofarads for the general class of FET's under discussion.

In order to fabricate both *n*- and *p*-channel MOSFET's on one crystal die, the processes shown in Fig. 3 may be employed. When this is done, we have the basic CMOS structure. Several devices may be interconnected to form a gate structure as shown in Fig. 4. Because MOSFET's are relatively simple to fabricate and do not have tight process limits, yields are high and costs relatively low, making them suitable for large-scale-integration (LSI) applications. The fabrication of several thousand MOSFET's on one chip is now routinely done by manufacturers, although a discussion of these circuits is outside the scope of this article.

The *standby* power dissipation of a CMOS circuit is the sum of the leakage currents of the individual elements multiplied by the supply voltage. During switching, as in the case of bipolar complementary pairs, both *n*- and *p*-channel pairs are "On" during the transition; hence, the power dissipation is again a function of the switching frequency and is proportional to fCV^2, where the C factor is the capacitive loading of the output, V is the supply voltage, and f the switching frequency.

The very high resistance of the gate circuit can lead to the collection of a static charge sufficient to destroy the IGFET, unless preventive measures are taken An extremely simple "fix" is to maintain a short-circuiting connection between the external terminals whenever the IGFET is not connected into a circuit.

A better solution is to fabricate zener diodes and ordinary signal diodes to provide a discharge path around the IGFET whenever voltages build up from static charge. In the same way, a path may be included to protect the IGFETs from damage when the power supply is turned off and a low-impedance drive source continues to supply input power.

A CMOS Device

To gain some insight into the numbers involved, let us look at a commercially available CMOS unit, the *RCA* CD4002, designated as the COSMOS (complementary-symmetry MOS) line by the company. The schematic and logic diagrams for the CD4002 are shown in Fig. 5. This chip consists of two 4-input gates in a *nor* structure for positive logic. The device is characterized for V_{DD} of 10 volts with

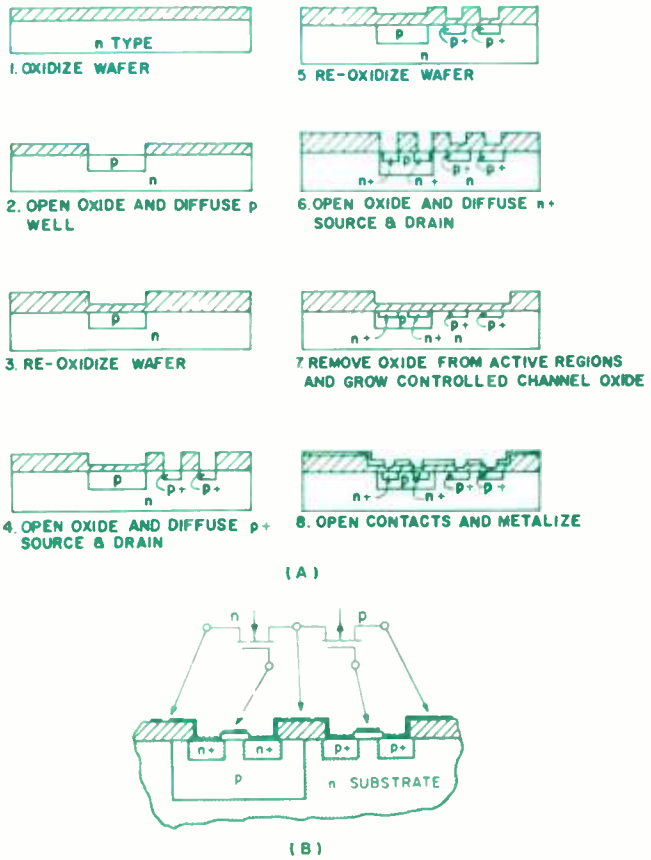


Fig. 3. (A) Processing steps used by RCA to fabricate complementary MOS integrated circuits. (B) Cross-section of finished CMOS integrated circuit with external connections.

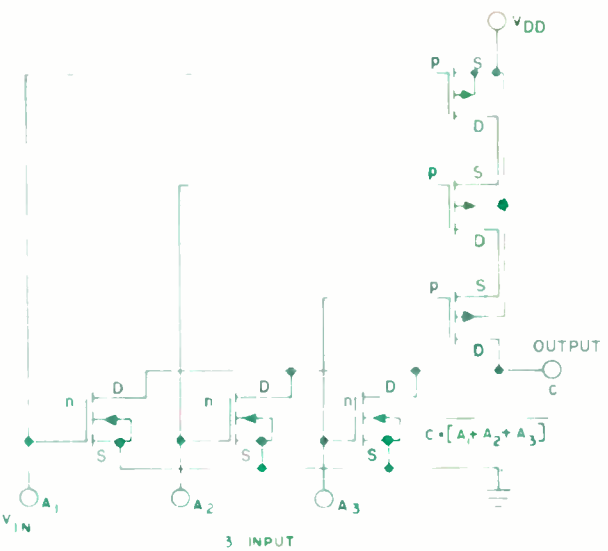


Fig. 4. Schematic diagram shows how several CMOS devices can be interconnected to form a 3-input "nor" gate circuit.

standby power of, typically, 10 nanowatts per gate. At 1-MHz operation and 10-volt supply, power is approximately 1 milliwatt. Noise-immunity is given as typically 45% of the supply voltage with a fanout in excess of 50. The output impedance is 1.5k which is extremely low in view of the nature of the loads to be driven.

The input capacitance of a CD4002 terminal is 5 pF (typical) and, for an output load of 50 pF (10 typical loads), the propagation delays to a logical "0" and a logical "1" are 400 and 200 nanoseconds, respectively. With the source terminal grounded, the logic levels are ground and V_{DD}, which means the logic swing is maximized, using the entire availa-

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Noise Filters in Hi-Fi Amplifiers

By JULIAN D. HIRSCH/Hirsch-Houck Laboratories

Here is how those high-cut and low-cut filters reduce interfering noise without too much loss of the desired hi-fi program material.

NOISE—any undesired addition to the signal or program—is a universal problem affecting such diverse areas as space communications and high-fidelity sound reproduction. No matter what portion of the frequency spectrum is involved, the problem resolves itself to one of limiting bandwidth—the frequency range within which the signal is contained. This is because random noise ("hiss" to the audio man) has a uniform distribution of energy per unit of frequency bandwidth.

The amount of noise power in a 10-kHz band is ten times (10 dB) greater than that in a 1-kHz bandwidth, all other factors being equal. This relationship applies whether the frequency band involved is between 3000.00 and 3000.01 MHz (as it might be in a microwave communications system), or the 10-kHz audio range itself.

In communications service the bandwidth can often be sharply limited, since intelligibility rather than "hi-fi" is the prime goal. Not so in the world of high fidelity, where we strive constantly to extend the frequency range. With this extension comes a proportional increase in noise power, at a rate of 3 dB/octave (or the equivalent of 10 dB/decade, a 10:1 range of frequencies).

The noise power in the range of frequencies up to 8 kHz, which contains most of the program material we listen to, is the same as that in the octave from 8 kHz to 16 kHz. This suggests that removing all frequencies above 8 kHz from the reproducing system could have a very small effect on the desired program, while cutting the noise power at least in half. In this very over-simplified treatment of what is really a very complex subject, we are ignoring such important considerations as the relative audibility of noise in different frequency ranges, but our purpose is to establish the rationale for filtering, or limiting reproduction bandwidth to that of the essential program material, when noise level is a problem, and to show some of the desirable attributes of such a filter.

The high-frequency pre-emphasis in FM broadcasting and the recording equalization boost of high frequencies are designed to take advantage of the noise/bandwidth relationship to improve the over-all signal-to-noise ratio. By boosting the signals at high frequencies in recording or transmission and rolling off the high-frequency response at the same rate in playback or reception the program frequency response remains unchanged, but noise introduced along the way is reduced by the 6-dB/octave playback equalization de-emphasis.

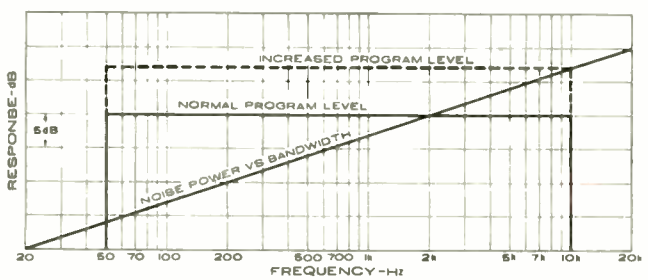


Fig. 1. A hypothetical hi-fi program that is mixed with random noise. Program level can be raised to overcome noise but to do so may result in system overload and excessive distortion.

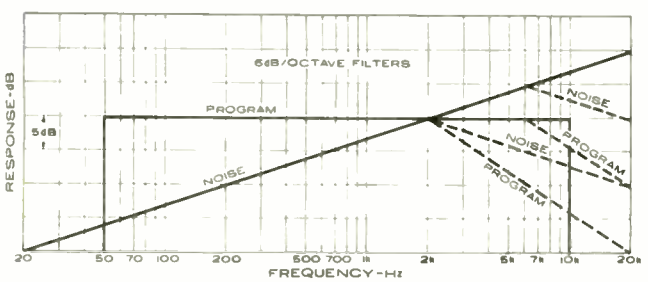
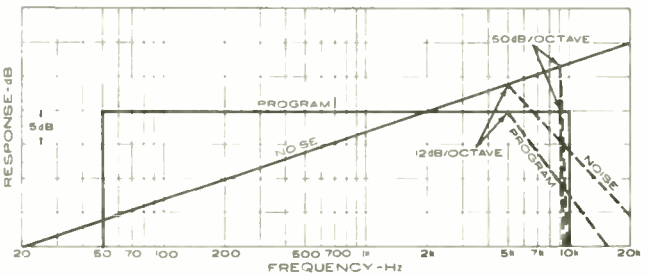


Fig. 2. The effect of using 6-dB/octave filter cutting off at 2 kHz and 6 kHz. Although the 2-kHz filter removes a sizeable percentage of program, result is a quiet background.

Fig. 3. Effects of 12-dB/octave filter cutting off at 5 kHz and much more elaborate 50-dB/octave filter cutting off at 9 kHz.



High-Cut Filters for Hiss

Even after all this has been done, there may be some audible hiss remaining, and this is why many hi-fi amplifiers and receivers are equipped with filters. The *high-cut* filter (really a *low-pass* filter, but commonly identified as "high cut" on amplifier or receiver panels) attenuates output above its *cut-off* frequency. Program and noise are equally affected, but as we will show, it may be possible to remove much of the noise with little effect on the program.

The amplifier designer must make two choices—the filter cut-off frequency and its slope (the rate at which the response changes beyond cut-off). The simplest filter circuits have a 6-dB/octave slope, and these predominate in present-day amplifiers and receivers in all price ranges. The cut-off frequency is typically between 2 kHz and 6 kHz. The higher cut-off frequency has a less drastic effect on the program sound, but is correspondingly less effective in removing noise.

Fig. 1 shows a hypothetical situation of a hi-fi program mixed with random noise. The solid-line rectangular curve represents the 50-Hz to 10-kHz bandwidth of the program. The sloping line indicates the cumulative noise power as the frequency is increased, with the 3-dB/octave slope showing that the power doubles with each additional octave of frequency.

Notice that the noise curve intersects the program curve at 2 kHz. If we assume that noise will be audible whenever

(Continued on page 68)

SOLDER and SOLDERING TOOLS

By JOHN FRYE

Methods, materials, and tools used to make good soldered connections. Here's what's available in solders, irons, guns, and desoldering tools.

This industrial GE soldering iron uses tips with insulating ceramic coating on one side in order to prevent electrical short circuits if the tip contacts two terminals at same time.

ASK any service technician if he really knows what he is doing when he solders a connection, and he is likely to be insulted; but the painful truth is he may not. Soldering is like driving; everyone is satisfied with his own performance and feels little need for study, but that doesn't mean there is no room for improvement. A high percentage of assembled kits returned to the *Heath Company* for repair involve poorly soldered connections and I strongly suspect a lot of those connections were made by practicing technicians who haughtily ignored the clear instructions and illustrations on how to make good soldered connections.

This article will treat soldering more as a science than as an art and it will outline the basic principles involved in making good soldered electrical connections in the service shop or the customer's home. Materials, tools, and methods involved in making such connections will be discussed and illustrated with representative equipment. Manufacturers of such equipment are listed along with their addresses so further information can be secured directly, if desired.

"Solder" comes from the Latin *soldare* "to make solid," and can be defined as the metallurgical joining of two or more metals at temperatures below their melting points by means of a low-melting-temperature filler metal. Common soft solders are tin/lead alloys with melting temperatures below 600°F. The term "hard solder" is properly applied to brazing alloys having a much higher melting temperature. "Silver solder" is such an alloy, melting at 1200-1500°F. Sometimes the term is loosely applied to tin/lead alloys to which a small amount of silver has been added to make temperature-resistant alloys melting in the 600-800°F range.

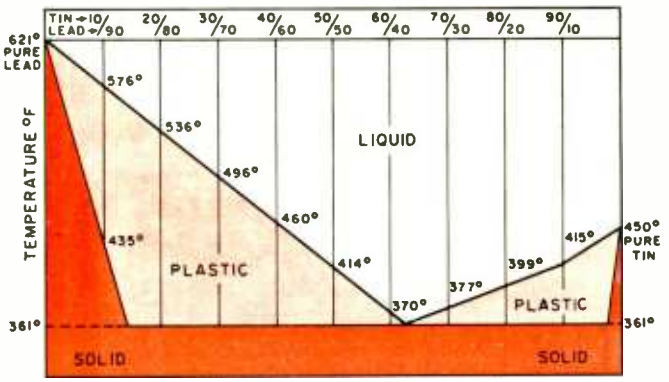
How Soldering Occurs

Unfortunately, authorities—which in this case means solder manufacturers—do not agree on the precise manner in which the soldering action takes place. Some say solution occurs between the solder and the soldered material. Note "solution" does not mean "melting." Salt can be melted only with a very high temperature, but it dissolves readily in water. Compare solder action to the moist tongue of a cow licking a block of salt. The moisture dissolves the salt into a brine that is neither pure water nor pure salt. In the same way, according to these authorities, the liquid solder exerts a solvent action on the copper or other material being soldered which produces a new and different alloy at the interface. The soldered joint is thus chemical in character rather than purely physical.

Other manufacturers, while admitting copper is soluable in molten tin, insist soldering relies on wetting for the bond formation and requires neither diffusion into nor melting of the base metal to secure bonding. But most authorities agree that soldering is the easiest, fastest, least-expensive, most widespread, and all-around most satisfactory method of joining in the electronics industry. A good soldered connection, having complete metal continuity, is liquid and gas tight, resists all thermal and mechanical stresses, and is excellent for electric-current conduction.

Fig. 1 is of major importance in understanding the nature of solder. It shows the behavior of various tin/lead solder alloys with regard to temperature. Note pure lead melts at 621°F. As tin is added, the melting temperature drops along a straight line until the 63/37 mixture (63% tin, 37% lead—tin is always given first) is reached. At this point the composition switches sharply from liquid to solid or *vice versa* as the 361°F temperature is crossed. As more tin is added, the melting point rises more gradually until pure tin is reached which then melts at 450°F. But for all tin/lead ratios other than the *eutectic* composition—the composition with the lowest melting temperature—there is a mushy range lying

Fig. 1. The tin-lead fusion diagram. Lowest melting temperature occurs with 63% tin and 37% lead combination alloy.



RULES FOR SOLDERING

1. The eight "rights" of making a good solder joint are: right material to be soldered, right cleaning, right solder alloy, right flux, right solder tool, right bit temperature, right amount of solder, and right amount of heat.

2. A clean, well-tinned bit is a **must** for good soldering.

3. The iron should heat the material; it, not the iron, should melt the solder.

4. A critical visual inspection is the only test needed to detect poor solder joints—**if you know what to look for.**

5. If you cannot see the outlines of the items soldered together, the solder has not flowed and wetted the metal as it should, or you have applied too much solder. In the latter case, you can't properly inspect the joint.

6. If the solder looks dull or frosted instead of shiny, insufficient heat has been applied to melt all the alloy completely, or joint components have moved while the solder was cooling.

7. Making a good mechanical joint before soldering is the best way to avoid cold-solder joints resulting from movement.

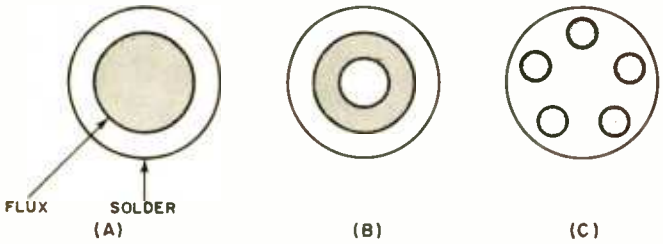


Fig. 2. Various solder and flux arrangements of cored solder.

between complete liquidity and solidity in which the solder is in a semi-liquid or plastic state.

Let's see why this is so. Any composition containing less than 63% tin can be considered a eutectic composition *plus additional lead*; any composition containing more than 63% tin can be considered a eutectic composition *plus additional tin*. When the temperature of a non-eutectic composition drops below the liquidity temperature, crystals disproportionally rich *in the additional metal* form and rapidly subtract this metal from the liquid composition until the latter reaches the eutectic mixture. Then the temperature stays at 361°F until all the eutectic has solidified because the eutectic solidifies sharply at only one temperature. This effect is put to good use in the formation of body and wiping solders that can be applied completely liquid and then worked and shaped in the plastic state before solidifying. It is a disadvantage in electronics work because solders widely removed from the eutectic composition require more heat to melt and more time to set. However, a 60/40 composition is very near the eutectic and is the most popular solder used in service work.

Importance of Flux

But more than the right solder composition is needed to make a good soldered connection. All metals form oxides on surfaces exposed to the air that prevent proper wetting of those metals by the liquid solder. If a weathered copper rod is dipped into molten solder, the solder will not adhere to it; but if that rod is broken beneath the surface of the molten solder, the latter readily bonds to the non-oxidized fracture surfaces. Obviously the oxide must be removed to insure a good soldered joint.

A material used to remove oxides and to keep them removed during the soldering operation is called a flux. Note a flux is not designed to remove any material except metallic oxides—not grease, not paint, not shellac, not dirt. These must be taken off first by other agents or methods.

There are three major types of fluxes: the *chloride* or "acid" type, the *organic* type, and the *rosin* or resin type. *Kester* insists that the word "acid" applied to the first type is merely a name describing the high activity of this type. The manufacturer says these "acid" types are actually solutions of one or more inorganic salts, being the halide or the phosphate of zinc, aluminum, calcium, magnesium, or tin. These fluxes are hygroscopic and, while hard and dry immediately after soldering, the fused residue gradually absorbs air-borne moisture that dilutes it and causes it to spread over a wide area, where it corrodes and becomes conductive. Hence, chloride fluxes, including soldering paste, are not suitable for fine electronics work. If this type of flux is used, it should be washed away with hot water or steam, and then the soldered unit should be thoroughly dried.

Organic-type fluxes are made up of mild organic acids and bases and their hydrohalides. While almost as active as inorganic salts, these fluxes have shorter periods of activity, which affords a means of limiting or controlling corrosion. They are not hygroscopic, and their dry and withered residues are easily removed by flaking, tumbling, or wiping with a damp cloth. These fluxes are useful where fast soldering is essential and where a certain minimal amount of corrosion can be tolerated, or where the flux residue can be easily removed.

Rosin and certain resins come close to being the perfect flux for electronics work because they do a good job of oxide removal and because their residues are completely noncorrosive and non-conductive. Note rosin *is* corrosive while in the heated liquid form—that's why it can do a good job of removing oxides—but in the solid form is absolutely inert and non-conducting. In other words, it works hard under the influence of heat from the soldering iron but "boats its oars" when the heat is removed. The electrical resistance of a cubic inch of rosin is 3300 trillion ohms. Many fluxes contain "activated rosin," which means the natural material has been subjected to a complex chemical process to increase its fluxing action without impairing the non-corrosive properties of the original rosin.

Flux makes another contribution to the wetting of metal by molten solder by affecting the surface tension of the latter. This is essential to the spreading or "feathering" of the solder. Without this, the solder tends to assume a high profile like a drop of water on an oily surface. Where the spreading solder stops, the dihedral angle formed by the sloping surface of the solder and the surface being soldered is a measure of the flux action: the smaller this angle, the better the flux has done its twin jobs of sweeping away the oxides and influencing the surface tension equilibrium in the direction the solder is spreading.

In some soldering operations, such as gutter and downspout installations, a liquid flux is brushed on the galvanized metal first and then bar or solid-wire solder is applied. However, most electronic repair soldering is done with cored wire solder; *i.e.*, the flux material in a solid, powder, or paste form is continuously present within a small-diameter tubing of solder. To insure the proper ratio of flux to solder and to have the two melt in proper sequence, various manufacturers have devised different methods of enclosing the flux within the solder. *Kester* places it in the center as shown in Fig. 2A. *Alpha Metals* does the same with its Uni-core Leak-pruf acid solder and its Hi-cor organic flux, but uses the configuration of Fig. 2B for its Cen-tri-core rosin-filled solder. *Ersin* Multicore employs five separate cores of its flux spaced just inside the circumference of the wire as shown in Fig. 2C, and different colors of flux are

used to identify all standard Multicore alloys. This 5-core configuration is carried out in all sizes of wire solder from #10 standard wire gauge to #34—the latter being only 0.009" in diameter, small enough to be threaded through the eye of a needle!

It has already been mentioned that silver is sometimes added to tin/lead alloys to elevate the melting temperature. Other materials will lower the melting temperature. A tin-lead-cadmium composition has a eutectic of 295°; a tin-lead-bismuth composition can be made to melt at 204°F. Solders with different melting temperatures permit "piggy-back" soldering in which a first joint is made with high-temperature solder and then another component is added with low-temperature solder so the original joint is undisturbed.

It is beyond the scope of this article to list all forms and varieties of solder offered by the companies mentioned, many of which are specifically designed for industrial soldering applications; but the keyed listing gives some idea of what is available from each. A query to any one of the companies will bring full information on their products.

Materials to be soldered must be raised above the melting temperature of the alloy. This is done in many ways in industrial soldering—dip pot, wave method, oven or hot plate, electrical resistance, induction heat, etc.—but in service work only the electric soldering iron, gun, and the torch are ordinarily used to apply heat.

The Electric Soldering Iron

The electric soldering iron is the most popular soldering tool. The function of the iron is to apply sufficient heat to the joint being soldered to melt the flux and the solder without transferring so much heat that surrounding material, such as insulation or a printed-circuit board, is damaged. Ideally, the temperature of the soldering iron tip should be about 100°F higher than the melting temperature of the alloy being used, both before and during the soldering operation. At the same time, the size of the components being soldered and the proximity of other components or conductors place mechanical limits on the size of the soldering tool. The result is there is no such thing as a completely satisfactory universal soldering iron; but manufacturers offer a wide range of soldering irons and guns to meet every need.

The bit temperature of the iron is controlled in various ways: by limiting the wattage of the heating element, by manually controlling the voltage applied to that element, or by using thermostatic controls. Light-weight pencil-type irons in the 8-25 watt range, working at the line voltage or at 6, 12, or 24 volts through a step-down transformer, are used for fine work where the light weight and short length of the iron permits precise direction of the bit. Such irons are offered by *American Beauty, Edysn, GE, Hexacon, Ungar, Weller,* and *Wall.*

American Beauty makes a temperature-regulating stand that drops the voltage on an iron resting on it to produce an idling temperature but applies full voltage when the iron is removed from the stand. *Hexacon, Ungar,* and *Wassco* make control units into which any conventional iron may be plugged and the voltage—and consequently the working temperature of the iron—can be manually adjusted to suit the job.

Another approach is the fully automatic temperature-controlled iron. *General Electric* and *Weller* are two companies manufacturing these. *Weller* has an interesting method of temperature control. At the back of the copper tip is a temperature-sensing element of material that is magnetic when cold but that ceases to be magnetic when its temperature reaches its Curie point. The cold element attracts a permanent magnet which closes a spring-loaded switch and applies power to the heating element. But when the bit temperature reaches the Curie point of the sensing element, the permanent magnet is no longer attracted and the power is cut off until the temperature falls below the critical temperature. By simply inserting tips with different Curie points, the working temperature of the iron can be maintained in the vicinities of 500, 600, 700, or 800°F.

With integrated circuits, any exchange of accumulated charge between the soldering bit and the circuitry containing the IC becomes a matter for concern. So these manufacturers provide grounded tips, isolated tips, or irons working

Single-post soldering gun from Wen being used on a PC board.

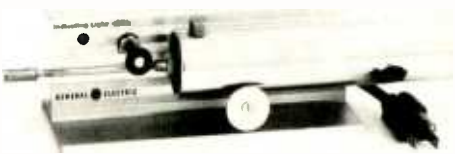
Conventional dual-wattage solder gun manufactured by Weller.

Soldering iron from Ungar has replaceable heating element.

Combination desoldering-resoldering iron made by Endeco.

Miniature gas welding, soldering torch from Tescom Corp.

A new, cordless, rechargeable battery-operated iron from GE.



through isolating transformers for soldering such circuits: *American Beauty, GE, Hexacon, Ungar, Wassco, Weller,* and *Wen.*

Another approach to this and the portability problem is the recent development of battery-operated rechargeable soldering irons by *GE* and *Technical Equipment Co. GE's* iron is rated at 19 watts and reaches an operating temperature of 900°F in 15 seconds. Three nickel-cadmium batteries in the handle of the iron produce 3.6 volts and can be recharged overnight. Weighing 21 ounces, it comes complete with batteries and recharging unit. *TEC's* Express 2000 has a rating of 40 watts with its standard tip or 25 watts with its fine tip. It is powered by a heavy-duty 1.25-V, 10-Ah nickel-cadmium cell that provides 120 to 500 solder operations on a single charge. Battery life is said to be better than 3000 recharge operations. Weighing 20 ounces, it comes complete with battery, but the charger is offered as an accessory.

The Solder Gun

Back in the 1930's Carl Weller, a radio technician, invented a new concept in solder-melting equipment, the *solder gun.* The heating element is also the solder bit in this tool and consists of a specially formed copper conductor whose maximum resistance is at a wedge-shaped tip. This conductor is connected across a low-voltage, high-current secondary of a transformer housed in a pistol-shaped plastic case. A trigger turns the gun on or off and sometimes selects either of two operating temperatures. *Edysn, Ungar, Weller,* and *Wen* all make solder guns.

Advantages of the solder gun are: quick heating and cooling, a small easily maneuverable tip, no expensive element to burn out, some ability to control the temperature with the trigger. Disadvantages include the weight and bulk, the heavy a.c. flowing through the tip, the necessity to operate the small tip at a high temperature to compensate for the lack of a heat reservoir, and the fact that extensive magnetic fields ordinarily surrounding solder guns preclude their use where such fields can be detrimental. *Ungar, Weller,* and *Wen* have all come out with guns to combat these problems.

Ungar's #6760 solid-state solder gun features a rigid grounded isolated tip for protecting sensitive IC's. Solid-state components replace a heavy, field-generating transformer, and the iron weighs less than five ounces. Instant selection of two temperatures—500°F or 900°F—is had with a switch separate from the on-off trigger. *Wen's* Model 450 All Gun is temperature-controlled and has three rigid replaceable tips: a "pencil" tip (25-100 watt heat-power range) for printed-circuit boards, a 100-200 watt heat-power tip for home wiring and appliances, and a 200-450 watt heat-power tip for gutters and plumbing. A flat iron attachment for removing dents and a plastic cutting attachment are available. It weighs 35 ounces. *Weller's* Model GT-7A soldering tool is also temperature-controlled and features interchangeable power heads that are ejected by a push of a button. Soldering points of the power heads have a special plating said to hold up for more than 30,000 solder connections. The tool weighs seven ounces.

Before the service technician solders a new component into a circuit, he ordinarily must "desolder" the old one and

(Continued on page 65)

MANUFACTURERS

Alpha Metals, Inc. ..... A,B,C,D,E
56 Water Street, Jersey City, N.J. 07304

American Beauty,
Div. American Electrical Heater ..... F,G,H,J,L,R,S
6110 Cass Ave., Detroit, Mich. 48202

Consell ..... Q
Nutmeg Ridge, Ridgefield, Conn. 06877

Edsyn Inc. ..... F,M,Q
15954 Arminta St., Van Nuys, Cal. 91406

Enterprise Development Corp. (Endeco) ..... R
5127 East 65 St., Indianapolis, Ind. 46220

General Electric ..... F,G,H,I,J,K,R
2100 Gardiner Lane, Louisville, Ky. 40205

Hexacon Electric Co. ..... G,H,J,L,P,Q,S
119 W. Clay Avenue, Roselle Park, N.J. 07204

Kester Solder Co., Div. of Litton Industries ..... A,B,C,D,E,F
4201 Wrightwood Ave., Chicago, Ill. 60631

Mann, Henry, Inc. ..... R
Box 65, 925 Pennsylvania Blvd.,
Feasterville, Pa. 19047

Microflame Inc. ..... T
3724 Oregon Ave., Minneapolis, Minn. 55426

Multicore (Ersin) Div. of British Industries Co. ..... A,B,C,D,E
Westbury, N.Y. 11590

Technical Equipment Co. ..... K
P.O. Box 247, Bothell, Washington 98011

Tescom Corp. Instrument Div. ..... T
2633 Fourth Street, S.E., Minneapolis, Minn. 55414

Ungar Div. Eldon Industries, Inc. ..... F,J,L,M,O,P,R
233 E. Manville St., Compton, Cal. 90220

Wall Manufacturing Co. ..... F
Kinston, N.C. 28501

Wassco (Glo-Melt) Div.,
American Electrical Heater ..... J,L
6110 Cass Ave., Detroit, Mich. 48202

Weller Div., Cooper Industries Inc. ..... A,F,G,H,I,J,M,N
100 Wellco Rd., Easton, Pa. 18042

Wen Products Inc. ..... J,M,N,P
5812 Northwest Hwy., Chicago, Ill. 60631

KEY TO PRODUCTS

SOLDERS
A. Cored tin/lead
B. Bar
C. High-temperature
D. Low-temperature
E. Separate fluxes

SOLDER IRONS
F. Pencil-type
G. General-purpose
H. Heavy-duty
I. Temperature-regulated
J. Irons for IC work
K. Battery-operated
L. Control units

SOLDER GUNS
M. Standard-type
N. Temperature-regulated
O. Guns for IC work

DESOLDERING EQUIPMENT
P. Tips
Q. Solder suckers
R. Irons
S. Wick-type material

MISCELLANEOUS
T. Torches

Larry Steckler
Editor
Radio-Electronics

Wayne C. Leckey (Top)
Home and Shop Editor
Popular Mechanics

Jim Hall
Designer of the
Chaparral 2J, world's
most advanced racing car

Match wits with the experts and win a $1000 shopping spree.

Three top pros challenge you to come up with an imaginative use for General Electric Silicone Seal or Silicone Lubricant. Something they may not have thought of.

Using the seal, electronics expert Larry Steckler repaired a speaker cone, and sealed an antenna lead-in feedthrough and outdoor antenna terminals. With the lube, he sprayed telescoping auto and TV antennas, a record changer mechanism and slide, and an antenna rotator.

With the sealant, home-and-shop expert Wayne C. Leckey dabbed rubber "feet" onto a trinket chest, sealed a rain gutter and caulked a bathtub. With the lube, he sprayed a fishing reel, some stuck drawers and all of his tools.

On his Chaparral 2J, Jim Hall used Silicone Seal to make formed-in-place gaskets, to seal all electrical connections, and as an adhesive to hold components to the body. Then he spray-lubed the throttle linkage, suspension ball joints, wheel lugs and battery terminals.

Now here's what you can do: send in another use for either product, different from those mentioned above, and enter our sweepstakes. (To win, all you *must* do is fill in your name and address and the name and address of the store where you saw GE Silicone Seal and GE Silicone Lubricant on display.)

Grand Prize: $1000 worth of anything from your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Next 100 prizes: $25 worth each. Next 1000 prizes: one-year subscriptions (or renewals) to the magazines from which you clip your official entry blank.

GE Silicone Seal: The most reliable adhesive/sealant/insulator/moisture-proofer/instant rubber. Guaranteed for 10 years. Ignores temperatures from —60°F. to 500°F. Won't harden, soften, crack or shrink. Ever. Dab it on, overnight it becomes a strong, flexible, permanent rubber. In white, black, clear and metallic. In 3-oz. tubes and 12-oz. cartridges.

GE Silicone Lubricant: The slipperiest stuff in a can. Longest wearing, strongest moisture resister, best corrosion fighter. Age, water and temperature (—70°F to 400°F) can't hurt it. *First lube of its kind that can be painted over.* Really works on just about everything, even aluminum. (Not recommended for TV tuners.) In 6-oz. aerosol cans.

GENERAL ELECTRIC

OFFICIAL RULES—NO PURCHASE REQUIRED

(1) On Official Entry Blank or plain piece of 3"x5" paper, print your name, address, zip code and the name and address of your favorite store carrying GE Silicone Seal and GE Silicone Lubricant. Include suggestions for new or different uses for either product, and name of magazine in which you saw this ad.
(2) Enter often, but mail entries separately to: MATCH WITS, P.O. Box 250, Murray Hill Station, New York, N.Y. 10016. Entries must be postmarked by July 5, 1971 and received by July 12, 1971.
(3) Winners selected in random drawings by an independent judging organization. Decisions final. *All* prizes awarded. Only one to a family.
(4) BONUS PRIZE: If you win the Grand Prize and your entry includes a new or different use, you receive a Bonus Prize of $100.
(5) Any resident of the U.S. is eligible except employees and their families of General Electric Company Silicone Products Dept. and its agencies. Void where prohibited. Subject to all federal, state and local laws and regulations.

OFFICIAL ENTRY BLANK

MATCH WITS
P.O. Box 250, Murray Hill Station
New York, N.Y. 10016

Here's what I did with (check one) ☐ GE Silicone Seal or ☐ GE Silicone Lubricant:_____

(attach extra sheet of paper for additional uses)

Name_____

Address_____

City_____ State_____ Zip_____

Name and address of my favorite store carrying GE Silicone Seal and GE Silicone Lubricant_____

Credo of a TECH WRITER

Mac and Barney learn what a free-lance writer feels about his work and his ethical obligations.

By **John Frye**

THE busy typing of Matilda, the office girl at Mac's Service Shop, was interrupted by the sound of someone vigorously kicking the front door which had been closed because of the air conditioning. Turning around, she saw the grinning face of J.D., a writer for technical electronics magazines who frequently dropped into the shop and was a great favorite of everyone there. He was hugging a big paper sack in each arm and obviously needed help. She ran to the door and opened it.

"Come on, Beautiful," J.D. called over his shoulder as he marched back into the service department. "We're going to have a picnic, and J.D. is treating."

Mac and Barney greeted him with bantering affection and demanded to know what ulterior motive was behind his generosity.

"Your suspicions wound me to the quick," the writer said as he began setting huge paper cartons of Coke, potato chips, a cheese dip, and a big can of cashew nuts on the service bench. "I just got to thinking of all the times I have dropped in here and picked the brains of you three for ideas for my articles, and I decided it was high time I called on you socially, without wanting a thing; and of course I didn't want to come empty-handed. So-o-o-o today, my esteemed friends, J.D. is at your service."

"Mac, that's the line the Greeks used when they offered the Trojan horse," Barney said. "Do you think we can trust him?"

"I doubt it, but let's do a little testing," Mac suggested. "Let's pick his brains for a change. Let's see if he will tell us how a tech writer ticks."

"You'll be sorry." J.D. warned, handing Matilda an ice-capped cup of Coke. "Asking a writer to talk about himself and his work is like breaching a dam. Just remember you asked for it.

"First off, I'll assume you're not interested in the ABC business of how you query an editor, prepare a manuscript, do illustrations, etc. That primer stuff you can get from any book on writing for publication. An experienced writer takes it for granted his manuscript should be pleasing to the eye, require a minimum of editing, and be easy to set in type. He does not expect the editor to have to do his work for him. I think you want to know something about how I feel about my profession and try to put into my writing."

"That's the idea," Barney said, tossing a cashew into the air and catching it in his mouth. "We want the behind-the-scenes goodies."

"Okay. I think a good tech writer is a true professional and acts like one at all times. He doesn't expect to write only when he feels like it. A deadline is a serious obligation to him and he makes every effort to meet it despite personal problems he may encounter. He is a responsible person. He realizes an editor publishing his writing is laying his editorial neck and the reputation of his magazine on the line in doing so. An editor cannot—and should not need to—double-check every statement the writer makes. He must have writers he can trust to be painstaking and accurate. The true professional is such a writer because he is just as concerned about what appears under his byline as the editor is about what appears in his magazine.

"My second belief is that a good tech writer is constantly 'stocking the pantry shelves.' By that I mean he must be constantly taking in and storing his mind with a wide range of knowledge from many sources: experience, magazines, books, newspapers, radio, TV, and talking with experts like yourselves. Note this knowledge doesn't necessarily pertain to a topic he plans to write about in the immediate future. A good writer is interested in *everything*, but it's amazing how much of what he learns he eventually converts into grist for his mill.

"Keeping informed is probably the most important activity of a writer, but he must not fall into the trap of becoming just a fact-collector in his own field. It's essential he perceive the relationship between what is going on there and what is happening in the rest of the world. He must develop a kind of side-looking radar that keeps him constantly aware of major developments in not only adjacent but in seemingly unrelated fields. Right now the biologist is calling on the computer and the electron microscope to help decode the secrets of the chromosomes, and store management is starting to rely on CCTV and the video recorder to help combat shoplifting.

"The tech writer must do a great deal of reading in his own special line, but he should also study how technical articles have been handled down through the ages. For example, reading a couple of 'construction' articles from the Bible, the story of Creation and the building of the Ark, should convince anyone you don't need five thousand words to tell how to put together a transistorized audio oscillator. Perusing Leonardo da Vinci's notebooks or Benvenuto Cellini's gripping account of the casting of the bronze Perseus will show the writer how a master handles a technical story. If he needs more to take the conceit out of him, let him read Ben Franklin's account of his early experiments with electricity or see how the Sage of Philadelphia got the jump on modern ecologists with his treatise on 'The Cause and Cure of Smoky Chimneys.'

"That brings me to another belief of mine. I think good technical writing should have warmth and humor and reflect the basic philosophy of the writer. I want a story to read as though *someone*—not a committee—wrote it! Some technical stories I read are about as colorless as computer-composed music. By saying a story should have warmth and humor, I don't mean the writer should deliberately try to be funny or precious. I simply mean the writing should show the author does not take himself nor his subject too seriously. Just because the subject is technical, the writing style does not have to be dry, stilted, and formal. The scientific writings of H.G. Wells and Julian Huxley prove the contrary. As a matter of fact, the more difficult and recondite the subject, the more the reader needs those little recesses for the mind provided by touches of humor that reassure him he is still in touch with another human being—the writer. Encouraged and rested, he can then press on to deeper understanding of the abstruse subject.

"At the risk of belaboring the point, I think technical writers have a deep responsibility, especially at this moment in time, to demonstrate technology is not necessarily cold and impersonal and anti-human. Right now we are on the brink of a revolt against technology. Just last week I heard a college president on TV expressing concern over the large number of students turning away from engineering and going into the humanities and social studies. He said people are distrustful of technology because it has failed to bring universal happiness and because many feel it has led us down the primrose path into a polluted world.

"There's reason for this feeling. Technology, as presented by many writers, seems to be trying to get rid of humanity. They speak of 'eliminating human error' as though man himself were a mistake. It's high time technical writers display technology as a servant of mankind, not its master; for as people see it, so will it become. Erich Fromm in 'The Revolution of Hope' quotes Marx as saying '. . . I can only relate myself in a human way to a thing when the thing is related in a human way to man.' If the rising tide of antipathy to technology is to ebb, we tech writers must relate things in a human way to men. Man must be plugged into any system planned. Mankind needs technology, but technology also needs man."

J.D. stopped to scoop some of the dip up on a potato chip and swallow it and then he continued: "Finally, I think the true professional has excellent relations with the editors and publishers with whom he works based on mutual respect. The vast majority of editors are fair-dealing, responsible business men dedicated to their job of turning out the best possible magazine month after month. They can't do it without writers and *good* writers make their job much, much easier. But writers must have a market for what they write; so the editor-writer relationship is one of mutual dependence."

"Hold it," Mac interrupted. "You say the vast majority of editors are fine fellers. Ever meet one who wasn't?"

A shadow wiped the cheerful smile from J.D.'s face. "Just one. Several years ago an editor friend asked me to dream up a regular monthly feature to help launch a new magazine. I came up with a continuing story that proved to be very popular and a good circulation builder. Several years later another editor I'll call B took over the magazine and started tinkering with my copy. He edited in some errors that made me look silly, and when readers caught them, he refused to admit in print they were editing errors. A good editor doesn't do that.

"Another editor I'll call A asked me to write a piece for his magazine. It was in no way related to what I was doing for B, and his rate of pay was two and a half times that of B. I did the piece and my name was featured on the cover. This made B furious. He wrote and demanded that in the future I either let him have first chance at anything I wrote or tell him what, where, and when I was going to publish. He intimated his magazine had 'made' my name, ignoring the fact I had been publishing regularly for many, many years.

"Of course I refused. Telling one editor what another was going to publish would be most unethical. I said as long as I remained a free-lance, being paid by the story, I would not submit to being controlled as though I were on salary. He refused to move from his position, so I terminated the series. In my forty-odd years of writing, he is the only editor who tried to pull that; and I don't think he tried it again because many other professional writers, getting wind of the incident, wrote and told me that if he tried it on them he would end up being blacklisted by all of us.

"But believe me, that joker is the exception and not the rule," J.D. said, his normal good-natured grin returning. "Let me show you how things usually go. Last month I got a telephone call from a favorite editor saying he was in a bind. At the last minute an author found he couldn't meet a deadline for an article already advertised. The editor wanted to know if I would try to get the article out on very short notice if he sent all the material that had been collected—and there were pounds of it—to me air mail-special delivery. I didn't tell him I had just refused requests from two publishers to do books because personal problems made me very short on time. I simply said, 'Shoot the material to me and I'll do my best.' No mention whatsoever was made about payment, and I didn't even think about it. I just knew my friend was in trouble and I wanted to help. I worked on the article almost continuously and finished it in plenty of time for the magazine to work up the art on it. Editor B will never know that kind of loyalty from a writer.

"Well," J.D. said, standing up and stretching until his muscles cracked, "I've kept you people from work long enough. Thanks for the use of the hall."

"I'll be glad to open the door for you any time you return with your arms full," Matilda answered, gathering up the empty cups, "even though you have sabotaged my diet for three days. You can't imagine how nice it is to hear some talk around here about something besides flybacks, purity, IC's, convergence, burst oscillators, and delay lines." ▲

BOOKS

"TV SERVICING MADE EASY" by Wayne Lemons. Published by *Howard W. Sams & Co., Inc.*, Indianapolis, Ind. 218 pages. Price $5.25. Soft bound.

Although this volume is technically a second edition, so many changes have been made in TV circuitry since 1962 that it has been extensively rewritten and updated to reflect these changes.

The author, a practicing service technician, has placed his emphasis on the needs of the working technician with a minimum of extraneous theory and a maximum of how-to-do-it-on-the-bench advice. In eleven chapters he covers the various sections of the TV receiver, circuits unique to color sets, and servicing procedures and techniques.

* * *

"PHOTOMULTIPLIER MANUAL" compiled and published by *RCA Electronic Components*, Harrison, N.J. 07029. 192 pages. Price $2.50. Soft cover.

This handy manual has been prepared to help designers and users of electro-optical equipment understand photomultiplier tubes and select the correct one for the job at hand. In 13 chapters, plus index, the scientists and engineers who collaborated on this book cover photoemission and secondary emission, principles of photomultiplier design, basic performance characteristics, statistical fluctuation and noise, applications, voltage-divider considerations, photometric units and photometric-to-radiant conversion, radiant energy and sources, spectral response and source-detector matching, technical data, outlines, and basing diagrams. Each chapter carries reference listings, illustrative material, and mathematical analyses of the text.

* * *

"FUNDAMENTALS OF ELECTRONICS" by E. Norman Lurch. Published by *John Wiley & Sons, Inc.*, New York. 817 pages. Price $12.95.

This is a book for technicians desirous of upgrading their skills and moving up in electronics. Used as a textbook in courses at The State University of New York at Farmingdale, the book is also suitable for home-study, provided the student has a working knowledge of d.c. fundamentals and understands a.c.-circuit operation.

The material, covered in 25 chapters, is presented in a straightforward, easy-to-understand manner with problems, review questions, and extensive illustrative data to permit self-checking or classroom assignment and testing. Answers are provided for selected problems.

* * *

"ENCYCLOPEDIA OF SCIENCE AND TECHNOLOGY" compiled and published by *McGraw-Hill Book Co.*, New York. 10,800 pages (15 volumes). Price $360.

This is the Third Edition of an encyclopedia which was originally launched in 1960, but so rapidly has science and technology advanced that this extensively revised edition became necessary. Most of the material from the previous editions has been revised and updated and almost 1000 new articles have been added. This edition boasts numerous 4-color photographs, more 2-color illustrations than previously, and the addition of almost 2500 new photos and/or sketches. Each topic is covered by a specialist in that particular field, with each discipline under the over-all supervision of a consulting editor who is a well-known authority in the field. Thus, Dr. Harry F. Olson is responsible for the material on açoustics, while Dr. Jacob Millman passes on articles about electronic circuits.

From the volume received for review it would seem that the editors and publishers have done an exceptional job of providing clear, succinct information on virtually any topic students, researchers, scientists, and engineers would be likely to require, inside or outside their own fields. Although distribution is expected to center on schools and technical libraries, families with scientifically oriented members might want this set for their homes too.

* * *

"ZENER AND AVALANCHE DIODES" by Carl David Todd. Published by *John Wiley & Sons, Inc.*, New York. 261 pages. Price $15.00.

This specialized text has been prepared for circuit designers and advanced electrical engineering students concentrating on semiconductor devices and circuits. It provides in-depth information on the characteristics and applications of zener- and avalanche-diode types of voltage regulators and covers basic device characteristics and applications.

The twelve chapters cover breakdown theory, characteristic parameters, voltage-regulation circuits, voltage-monitoring circuits, protection circuits, clamping and clipping, d.c. voltmeter scale expansion and a.c.-expanded scale voltmeters, level shifters and coupling, miscellaneous applications, special devices, and test methods and equipment.

The treatment is mathematical and the author has assumed that the reader has an electronics background of a fairly generalized nature. An extensive bibliography permits further study if the reader wishes to pursue any particular topic in more depth.

* * *

"THE RADIO AMATEUR'S HANDBOOK" by the Headquarters Staff. Published by *American Radio Relay League*, Newington, Conn. 06111. 610 pages, plus tube and transistor data and basing diagrams. Price $4.50 in U.S. Soft cover.

This is the 48th (1971) Edition of the amateurs' "bible" and bigger and better than ever. Revisions in both the theory and construction sections of the book make it a truly state-of-the-art reference for all facets of ham gear and operating practices.

Among the new construction projects are such items as solid-state transceivers, receiving accessories, and antennas. Solid-state receivers and transmitters have been added, along with new v.h.f. transmitting equipment.

As always, the tube and semiconductor data and basing section is outstanding—eliminating the necessity of consulting a number of tube and transistor manuals.

* * *

"ELECTRONIC MUSICAL INSTRUMENTS" by Norman H. Crowhurst. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 188 pages. Price $7.95.

This is a book for both the technicians who service and the performers who play electronic musical instruments. The author, who has a foot in both camps, explains how various instruments are "electronified," modifications of traditional instruments when they are to be electronically amplified, how to handle instrument amplification, and concludes with an extensive discussion of synthesizers.

Also included is an analysis of amplifier and speaker system requirements, troubleshooting traditional and electronic instruments, and a discussion of the career possibilities in the field. Since electronic organs have been covered extensively in other books, this class of instruments has been omitted from this volume.

Detailed diagrams, partial schematics, schematics, and photographs are used to pinpoint exactly what is to be done and how in connection with hooking up and maintaining various types of electronic musical instruments. ▲

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Low-Distortion Hi-Fi Volume Expander

By RICHARD WILT

An FET circuit that provides up to 30-dB expansion of dynamic range of recorded or broadcast music.

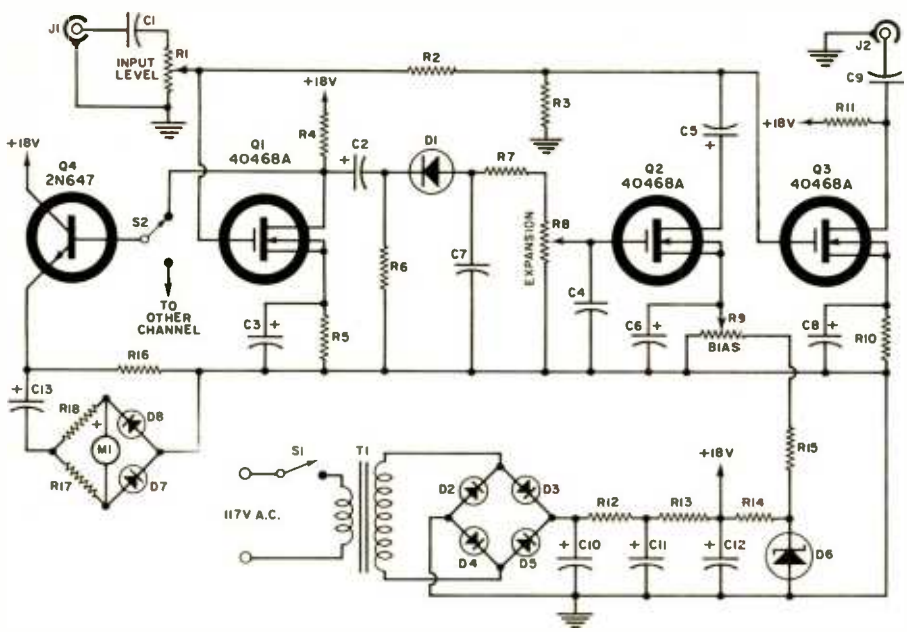
ONE of the major shortcomings of disc or tape recordings is the finite dynamic range available. In order to counteract the always-present system noise, recording companies use volume compressors and limiters to insure that the recorded signal falls within proper limits. If this were not done, the soft passages would be marred by a high background noise level, or the loud passages would overmodulate the disc or tape, causing severe distortion.

A device that can increase the dynamic range of recorded music is called a *volume expander*. It does this by amplifying strong signals more than weak signals. Ideally, the gain of a properly operating volume expander should be proportional to its input signal over its entire operating range.

The unit to be described uses a field-effect transistor as a voltage-controlled variable resistor in an attenuator network. Inexpensive parts are used, and one should have no difficulty building the unit for $30 or less.

An expansion ratio of over 30 dB may be obtained by proper adjustment of the bias control, but 20 dB was found to be the practical limit for most recordings. After all you don't want the softer music to disappear completely. The expander is designed to have a very short time constant (2 ms) for increasing sound levels, but a long time constant when the volume is decreasing.

Schematic and parts listing of volume expander which uses 3 inexpensive FET's. For stereo operation, a duplicate of the Q1, Q2, Q3 circuit would be required.



R1—250,000 ohm audio-taper pot
R2, R3—330,000 ohm, ½ W res.
R4, R11—3300 ohm, ½ W res.
R5, R10—270 ohm, ½ W res.
R6—10,000 ohm, ½ W res.
R7—10 megohm, ½ W res.
R8—3 megohm linear-taper pot
R9—2500 ohm linear-taper pot
R12—470 ohm, ½ W res.
R13—220 ohm, ½ W res.
R14, R15, R17, R18—1000 ohm, ½ W res.
R16—2200 ohm, ½ W res.
C1—0.05 μF paper capacitor
C2—5 μF, 25 V elec. capacitor
C3, C8—100 μF, 3 V elec. capacitor
C4—0.01 μF ceramic capacitor
C5, C6—5 μF, 10 V elec. capacitor
C7, C9—0.22 μF paper capacitor
C10, C11, C12—250 μF, 50 V elec. capacitor
C13—10 μF, 25 V elec. capacitor
S1—S.p.s.t. toggle switch
S2—S.p.d.t. slide switch
J1, J2—Pin or phono jack
M1—1 mA miniature d.c. meter
D1—Germanium diode (see text)
D2, D3, D4, D5—Silicon diode 200 p.i.v., 1 A (HEP 156)
D6—5 V zener diode (HEP 603)
D7, D8—1N34A germanium diode (HEP 134)
T1—24 V, 1 A filament trans.
Q1, Q2, Q3—RCA 40468A
Q4—2N647 (or HEP 641)

In the circuit shown, *Q1* amplifies the input signal and applies it to the half-wave rectifier *D1*. The resulting d.c. voltage is used to control the effective resistance of *Q2*, which is part of an audio-attenuator circuit. The resistance of *Q2* can change from several thousand ohms to several megohms with a gate voltage change of a third of a volt or so. The output of the attenuator is amplified by *Q3* to a level sufficient to drive most power amplifiers. Field-effect transistors are also used for *Q1* and *Q3* to avoid loading the attenuator network.

The meter circuit with its driver, *Q4*, make it easier to set the input levels correctly. A switch is provided to connect the meter to either channel. Almost any *n-p-n* audio transistor can be used for *Q4*.

A zener diode (*D6*) voltage regulator is shown in the power supply. The bias voltage is quite critical and, without the zener diode, line-voltage variations would cause large changes in the gain of the expander. The bias potentiometer should be a screwdriver-adjustable type and located on the rear of the expander. The power supply as shown will operate both channels of a stereo expander.

The control-signal rectifier (*D1*) must have a back resistance of at least 50 megohms to avoid shortening the time constant of the rectifier load circuit. A v.t.v.m. can be used to measure the back resistance of the diodes. A

germanium diode is preferable for *D1* because of its lower threshold voltage.

A time constant of about 3 seconds (0.22 μF and 13 megohms) was found to be about right for this circuit, although some people might prefer a shorter time constant. A 0.1-μF capacitor in place of the 0.22-μF unit shown for *C7* would reduce the time constant to 1.3 seconds. A shorter time constant than this would produce an annoying "blasting" effect.

Parts placement is not critical with the exception of the power transformer, which should be several inches away from the amplifier circuits to prevent hum pickup.

Alignment Procedure

The only equipment needed for alignment are a calibrated oscilloscope and an audio oscillator. Set the input level control at maximum and the expansion control at minimum. Apply a 100-mV 1-kHz signal to the input. Observe the level on the meter. This is the maximum signal level that should be reached during use. A red line on the meter at this level would be a good idea. Set the bias control for maximum signal on an oscilloscope connected to the output of the expander, then adjust the bias control for an output voltage one-tenth as great as the maximum (20-dB down). The bias should now be about 2 volts. If 30-dB expansion is desired, set the output at 0.03 of the maximum, but a hum problem could develop during use in this case.

Set the expansion control at maximum. This should restore the original output level. This completes the alignment.

A little practice may be required in setting the input levels correctly, but once set, the unit needs little attention. The expander would normally be connected between the preamplifier and the power amplifier. The listening volume is controlled by gain controls on the power amplifier. The preamp controls and input controls on the expander should be adjusted only as necessary to keep the input level correct as shown on the meter. The meter should kick to about half-scale on peaks.

Listening to an expander for the first time can only be described as startling, with most recordings sounding much more realistic. When the music stops, tape or record noise fades away in a fraction of a second. A very quiet listening room would really add to your enjoyment of this unit. Also desirable is understanding neighbors, as the music can get unbelievably loud at times. A curious effect is that the ear gets used to the increased dynamic range and takes it for granted. Then all you have to do is remove or bypass the expander and discover how dull things sound without it. ▲

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

By Harry Remmert

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

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

The Advantages of Home Study

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

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

FCC License Warranty Important

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

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

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for my Correspondent Counselor who has faithfully seen to it that my supervisor knows I'm studying. I think the monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. My Counselor has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction.

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands" . . . learning by taking things apart and putting them back together . . . soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men will be needed in virtually every field of Electronics, from two-way mobile radio to computer testing and troubleshooting. And with this demand, salaries have skyrocketed. Many technicians earn $10,000, $12,000 or more a year.

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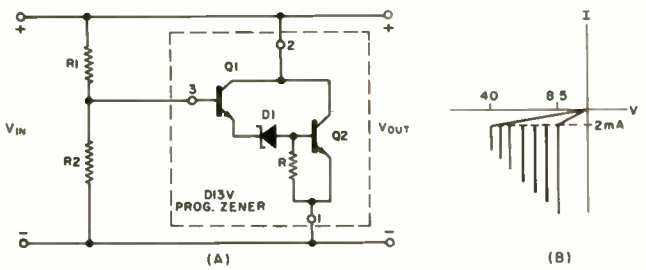
Programmable Zener Applications

By R. L. STARLIPER/Western Electric

This three-terminal device, providing a variable zener voltage, has many unusual applications.

THE programmable zener is a three-terminal semiconductor device capable of providing a continuously variable zener voltage with the input voltage fixed at some selected value. Basically, it consists of two transistors connected to form a Darlington circuit and a low-voltage fixed zener used to supply the reference voltage. The device was intended to be used as a programmable zener "diode" but has many other applications, as will be described.

The programmable zener of the type to be described is a low-capacitance, low-power, three-terminal device, as shown in Figs. 1A and 1B.



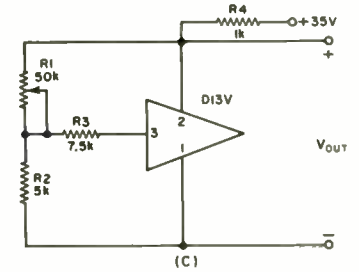
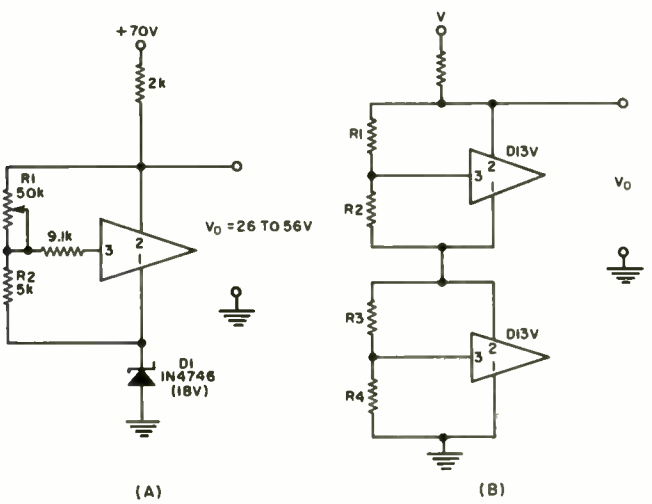


Fig. 1. (A) Programmable zener and (B) characteristics. (C) Typical circuit connection for programmable zener.

Fig. 2. Two circuit configurations useful for obtaining higher output voltages. Refer to discussion in article.



The circuit consists of transistors $Q1$ and $Q2$, a zener diode $D1$, and a resistor R connected in a high-impedance Darlington circuit, as shown within the dotted box (Fig. 1A). Programming is accomplished by the selection of proper values for external resistors $R1$ and $R2$.

When power is applied to the circuit through an external current-limiting resistor (not shown), the current flow through $R1$ to the base of $Q1$ biases $Q1$ on. The current from the emitter of $Q1$ flows through $D1$ to the base of $Q2$ and turns $Q2$ on. Under these conditions, the voltage from terminal 3 to ground is maintained at a fairly constant value, equal to the zener voltage of $D1$ and the base-to-emitter voltage of $Q1$ and $Q2$. As the values of $R1$ and $R2$ of the external divider change, the collector-to-emitter voltage across $Q1$ changes, causing the output voltage, V_{out}, to vary. The output voltage of Fig. 1A is given by:

$$V_{out} = V_r \frac{(R1+R2)}{R2} \quad \ldots\ldots (1)$$

For the commercially available D13V (*General Electric*) programmable zener, V_r ranges from 8.5 volts to a maximum of 10 volts. This device has a Thevenin input resistance of $R1R2/(R1+R2)$, which should be approximately 50k ohms to maintain good temperature stability (0.1%/°C). Fig. 1B shows how the zener characteristic changes as the values of the programming resistors, $R1$ and $R2$, change.

In actual use the programmable zener must be connected through a current-limiting resistor to a source of supply voltage, as shown in Fig. 1C.

In this circuit potentiometer $R1$ will control the output voltage from 8.5 to 30 volts using a 35-volt supply. Resistor $R4$ limits the current to pin 2 to less than 40 mA and $R3$ limits the base current to pin 3 to less than 5 mA.

If it is necessary to provide voltages above the range of the programmable zener, a conventional zener diode, $D1$, can be added in series with the programmable zener, as shown in Fig. 2A. The addition of $D1$ effectively moves the minimum zener voltage to a value equal to V_r (Eq. 1) plus the zener diode voltage. The circuit shown will supply a variable output from 26 volts to 56 volts with the addition of the 18-volt zener. Other combinations can be obtained, as shown in Fig. 2B, in which two or more programmable zeners are connected in series. For each programmable zener added the minimum zener voltage is increased by V_r of Eq. 1. With two programmable zeners, the minimum voltage would be in the range of 17 to 20 volts. The programming resistors $R1$, $R2$, $R3$, and $R4$ can also be made adjustable to give a variable output.

A basic application of the programmable zener is as the

reference element in a series regulator. A circuit using the D13V as a reference is shown in Fig. 3. In this circuit the programming resistor consists of the 10k-ohm potentiometer connected across the output of the regulator. The output at pin 2 of the D13V drives *Q1* and *Q2* to produce a constant output across load resistor R_L. With the circuit as shown, the output across R_L is variable from 10 to 25 volts at 1.5 amps. The regulating characteristics with different values for the load resistance are also shown.

A more unusual application of a programmable zener is in the pulse-generating circuit of Fig. 4A. In this circuit, *R1*, *R2*, *C1*, and *Q1* form a free-running relaxation oscillator. The external divider, which determines the output voltage of the programmable zener, consists of *R4*, *R5*, and the inter-base resistance of unijunction transistor *Q1*. When power is applied to the circuit, capacitor *C1* charges through *R1* and *R2* until the firing voltage of *Q1* is reached. When *Q1* conducts, its internal resistance decreases, thereby changing the divider resistance of the programmable zener. This sudden decrease in resistance causes the output voltage across *R7* to increase. The width of the output pulse is determined by the time the unijunction transistor remains in the "on" condition. This is controlled by the discharge time of *C1* through *R3*, *Q1*, and *R5*. With the component values shown, the output pulse amplitude is 6.5 volts with width variable from 50 to 850 μs, as determined by *R3*. When *Q1* returns to its high-impedance state, the entire cycle is repeated.

A free-running multivibrator can be constructed using two D13V programmable zeners, as shown in Fig. 4B. This is a standard multivibrator circuit in which the two switching transistors have been replaced by programmable zeners. As with a standard multivibrator circuit, the operating frequency can be altered by changing the value of the 1000-pF charging capacitors. The non-symmetrical output waveform is caused by the difference in characteristics of the programmable zener.

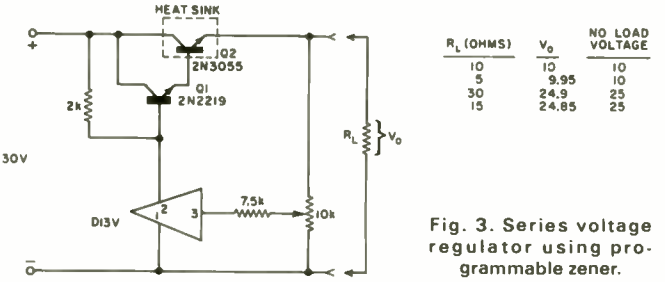
In pulse circuits it is sometimes necessary to limit the pulse amplitude to some selected value. If a fixed zener is used, the amplitude is limited to available zener voltages. Using a programmable zener in the circuit, as shown in Fig. 5, enables one to select amplitudes over a much wider range.

This circuit will limit 40-volt input pulses from 8.5 to 38 volts, depending on the setting of *R1*. This circuit was tested with the input pulse widths from 1 μs to 500 μs and at frequencies up to 9000 p.p.s. The risetime of the output pulse is degraded somewhat due to the capacitance and switching time of the programmable zener. If *R1* is set to some particular value, the output amplitude will remain constant as the input amplitude changes.

Constructing a Programmable Zener

A programmable zener, which operates on the same principle as the D13V, can be constructed from discrete components, as shown in Fig. 6. This circuit was built using readily available components and produced a characteristic curve as shown in the diagram.

The output voltage follows the theoretical value calculated from Eq. 1 for different values of programming resistors selected. The value of V_z in Eq. 1 was measured as 11.5 volts (0.6 + 10.3 + 0.6). A slight difference in the characteristic curve resulted mainly where the zener action begins. This circuit, however, requires only 1 mA reverse current to start zener operation whereas the commercially available D13V requires 2 mA. See Figs. 1A and 1B. If the reader constructs a circuit similar to that shown in Fig. 6, the internal zener (1N4740) should have a zener voltage above 6.2 volts to obtain the best results. Zener diodes with voltages below 6.2 volts work on the field-emission principle rather than avalanche and have a poor characteristic compared to the higher voltage zeners. With the proper selection of



R_L (OHMS)	V_o	NO LOAD VOLTAGE
10	10	10
5	9.95	10
30	24.9	25
15	24.85	25

Fig. 3. Series voltage regulator using programmable zener.

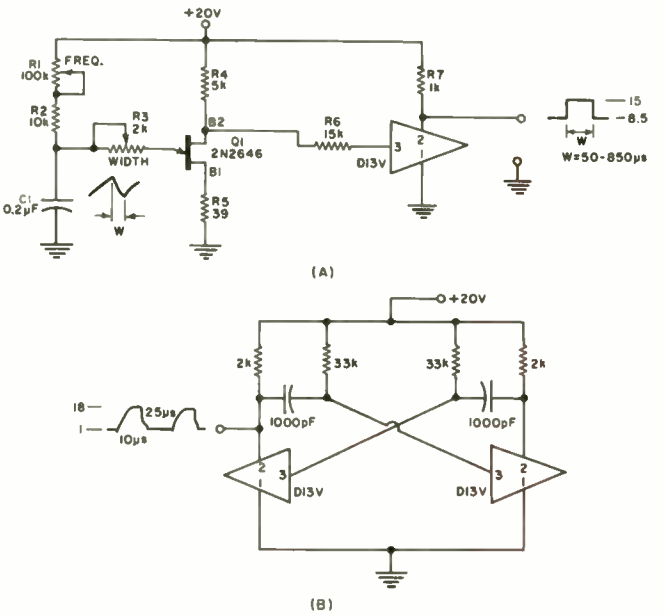


Fig. 4. (A) Pulse generator using programmable zener. (B) Free-running multivibrators using programmable zeners.

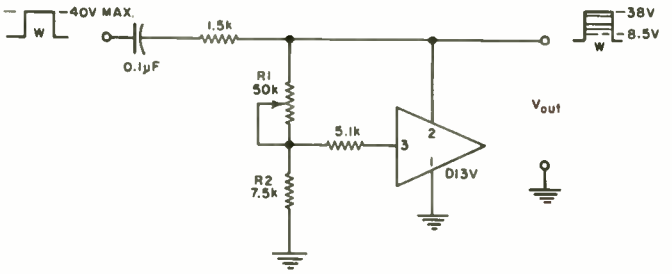
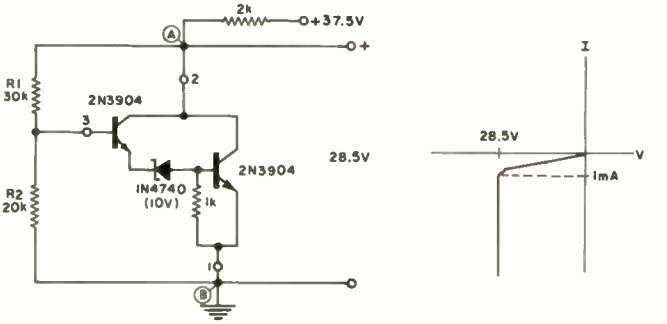


Fig. 5. A programmable zener used as a pulse clipper.

Fig. 6. A programmable zener built from discrete components.



transistors, other types of circuits can be constructed with higher power and voltage ratings.

If it is desired to observe the programmable zener characteristics on a transistor curve tracer such as the *Tektronix* 575, point A of Fig. 6 should be connected to the "Emitter" terminal, point B to the "Collector" terminal, and the device set for *p-n-p* operation. The 2k-ohm current-limiting resistor is then obtained from the curve tracer's "collector load" under "grounded-emitter" operation. ▲

Calibrating Digital Voltmeters

(Continued from page 36)

of the standard cell voltage (.1017586). Exactly 10 volts are now required from the variable power supply to obtain a null on the detector. Then connect the detector to the output of divider #2 and adjust divider #2 for a null. Connect the Lo input lead *X* of the d.v.m. to point Z. Divider #1 can now be set to obtain any value of voltage to 10 volts, in 1-microvolt steps, with an accuracy of approximately ±5 ppm. Any change in divider #1 will require a corresponding change in divider #2 to obtain a null. Adjustment of the d.v.m.'s internal standard reference can now be made along with calibration of the internal divider.

To determine if the 10-volt standard is accurate, an analysis of possible errors can be made. First, all switch, lead, and contact resistance was in the circuit when the power supply was adjusted. Second, the only change in the circuit was in the position of switch *S* 2 and the connection of the d.v.m. to the circuit as indicated above. Since no current is drawn from the divider by the detector or the d.v.m., there will be no voltage drop and the source will be at 10 volts, within the accuracy of the standard cell and the linearity accuracy of divider #1.

A standard voltage of 90 and 900 volts will be necessary to check the 100- and 1000-volt ranges. The Lo input to the d.v.m. is next connected to point Y, which connects the d.v.m. directly across the power supply. Switch *S* 2 is placed in the standard-cell position and switch *S* 3 is opened, removing divider #2 from the circuit.

A 90-volt standard could be obtained by leaving switch *S* 1 in position *B*, setting divider #1 to one-ninetieth of the standard cell value, and adjusting for a null. In our example, divider #1 would be set to .0113065. For a 900-volt standard, the setting would be .0011306. However, since one significant digit is lost in the first setting and two in the second, there would be a loss of resolution. *R* 1 and *R* 2 are used to extend the range of divider #1 to eliminate such loss of resolution.

For a 90-volt standard, place switch *S* 1 in position *A* and divider #1 now becomes 10% of the total resistance. The formula for determining the setting of divider #1 is E_{sc}/A 90. *A* is used in the formula instead of .1 because of the possibility of introducing errors when connecting the 900k-ohm resistor into the circuit. To find the true *A* value for the formula, set divider #1 to .0900000. Divide the standard voltage by .09 and set this value into the power supply. Set switch *S* 1 to position *B* and adjust the power supply for a null. Return switch *S* 1 to position *A* and change divider #1 to .9000000. If *R* 1 and the divider are accurate, a null will be obtained. If not, adjust divider #1 to obtain a null. Divide this final reading into .09 and record it as the true *A* ratio value. This, then, is inserted into the formula $S - E_{sc}/A$ 90 for the setting on divider #1. Using the computed setting, adjust the voltage standard for a null and an accurate 90-volt output.

To obtain a 900-volt standard, add *R* 2 to the circuit by switching *S* 1 to *N* and use the formula $S - E_{sc}/N$ 900. To find the true *N* ratio, it is necessary to reduce the setting ($S - E_{sc}/A$ 90) of divider #1 by 10% and adjust the power supply for a null with switch *S* 1 in position *A*. Set switch *S* 1 to position *N* and adjust the voltage divider for a null. Divide the divider #1 setting into .009 and use this as the true *N* ratio in the formula. Set the computed figure into divider #1 and adjust the power supply for a null. The output of the power supply will be 900 volts ±5 ppm.

Using the procedures, computed values, and formulas given, the internal power supply and all internal voltage dividers of a 1000-volt d.v.m. can be calibrated to the required accuracy. ▲

Solder and Soldering Tools

(Continued from page 48)

remove it. This is not always easy to do with printed circuits without damaging the board. When the component has several rigid connectors, as is the case with sockets, metal-can capacitors, etc., you have only two choices: all the connections—or at least all on one side—have to be heated simultaneously so the component can be lifted free or tilted, or the solder must be entirely removed from around each connection, one at a time. For simultaneous desoldering, *Hexacon*, *Ungar*, and *Weller* all produce desoldering tips for use with their irons. Some are shaped as single or double bars for unsoldering in-line contacts; others are cup-shaped for removing such things as tube sockets.

Desoldering Tools & Techniques

There are two approaches to removing solder from one contact at a time: the solder can be melted and vacuumed away, or it can be melted and made to transfer itself by capillary attraction or "wicking" onto a special metallic braid-type of material. Vacuum-type desoldering tools vary considerably. The simplest is merely a rubber bulb with a Teflon tiplet (*Hexacon's* Solder Sucker) for taking up solder melted by any iron or gun. *Ungar's* Model 7800, *Endeco's* Models 100A and 300, and *American Beauty's* Little Dandy are more sophisticated in that the bulb is mounted on a special low-wattage iron with a hollow tip through which the molten solder is aspirated. *Edsyn's* Soldapulit and Soldavac and *Consell's* Super Solder Vacuum are desoldering tools resembling a bicycle pump in which the spring-loaded plunger can be cocked in the "down" position. The tip is pressed into the molten solder and the plunger releases with a trigger, causing the sudden vacuum to suck up the solder. Finally, *Henry Mann* makes the Mighty Vac, in which a power unit supplies both a controlled voltage for the hollow-tipped iron and a continuous vacuum from a pump. *GE* makes the Model 6A680 desoldering tool in which the vacuum is produced by a venturi-tube effect caused by the passage of compressed air or Freon gas past an orifice.

As for capillary attraction desoldering equipment, *American Beauty* makes Dri-Wick "the desoldering tool on a spool," and *Hexacon* makes the Hex-Wik Solder Remover. The former comes in four widths; the latter in two. In either case, the end of the flux-coated metallic braid is laid on the joint from which the solder is to be removed and an iron is placed on top until the solder melts; then the wick is lifted off, taking the solder with it. The solder-soaked half-inch or so of braid is cut off and discarded.

Miniature Torches

We must not conclude our discussion of soldering tools without mentioning two miniature torches that can be used for heating. *Microflame* makes a completely self-contained torch, using miniature oxygen and LP gas cylinders, that produces a pin-point flame up to 5000°F to weld, braze, and solder. Because of the small size of the cylinders, the torch is not intended for heavy-duty use.

Tescom's Little Torch is designed to be used with acetylene, hydrogen, LP, or natural gas and will produce temperatures up to 6300°F, hot enough to melt weldable metals, glass, or ceramics. When purchased as a set, Little Torch comes with plastic hose, a variety of tips, and regulator gauges that fit commercial gas tanks. Both torches can produce micro-miniature flames that will pass through the eye of a needle.

The best way to become proficient at making good solder joints is to make lots of them, never being satisfied with anything less than perfection. Good soldering habits are among the best habits a technician can acquire. ▲

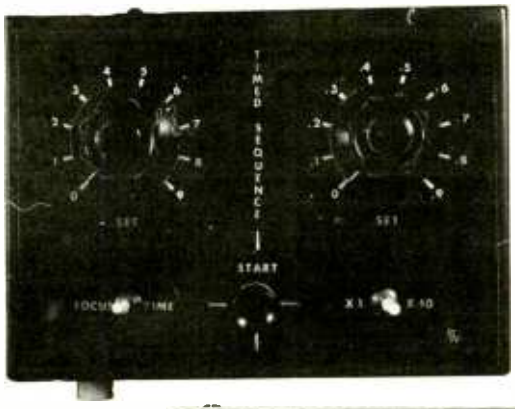
Solder manufacturers produce and package their products in wide variety of forms. Shown here are bar solder without flux, a wire solder with flux, and a liquid flux.

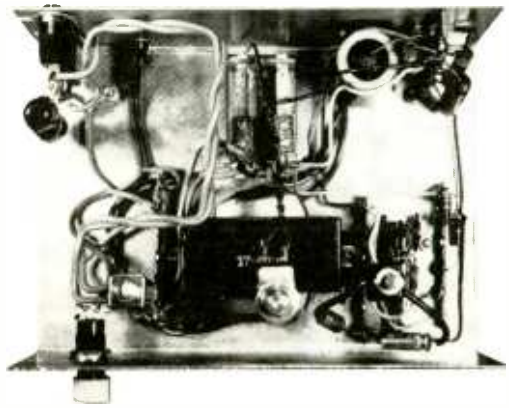
This soldering iron is operated from solid-state variable supply.

Solid-State Darkroom Timer

By ROY A. WALTON

Relatively inexpensive compact timer, using a UJT to trigger an SCR, provides timed intervals from 0.1 second to 99 seconds.





Two views of solid-state darkroom timer showing (top) operating switches and (bottom) internal view with front panel removed. Switch S4 and the 2 a.c. outlets can be seen on the lower- and upper-left corners, respectively.

ACCURATE timing in the one minute to one-tenth of a second range is one of the more difficult timed intervals to obtain. Timing circuits in this range usually require fairly bulky and expensive equipment as well as relatively high voltage to operate. However, the use of unijunction transistors and silicon controlled rectifiers reduces the bulk, cost, and high-voltage needs considerably.

The circuit shown in Fig. 1 uses a UJT ($Q1$) to trigger an SCR and provides for a 99-second maximum to a 0.1-second minimum time delay. Longer time delays can be obtained by increasing the values of $C4$, $C5$ or the timing resistors. (See Table 1.) The values of substitute resistors and/or capacitors that will provide longer timing delays can be found by using the formula: $T = 0.002\,RC$, where T is time in seconds, R is resistance in kilohms, C is capacitance in microfarads, and 0.002 is the "finagle" factor.

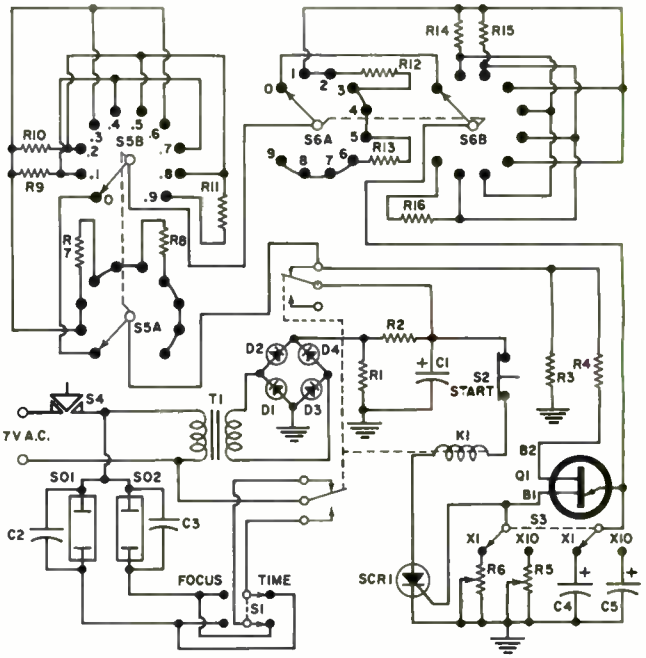
Repeatable accurate timing is a prime necessity in the photographic darkroom. For this reason, an enlarger timer, such as is described in this article, is required. Actually, any 117-volt a.c. device can be controlled by the timer diagrammed in Fig. 1. If it is necessary to use other control voltages, the relay ($K1$) can be wired for them. The timer can also be battery-powered if it is to be used away from the power lines. A timer of this type has a multitude of applications; its small size, portability, and low-voltage requirements are definite advantages.

After constructing the timer, perform the following check: 1. Set the "Set" switch, S6, to its "0" position, switch S5 to ".5" and switch S3 to "X1." 2. Turn on timer by pressing push-button S4 (see lead photographs). Relay $K1$ should close. 3. Press the "Start" button S2. The relay should open and then close. 4. Set switch S3 to "X10" and press S2. The relay should remain open about five seconds and then close. If this action is not obtained, $R5$ and $R6$ should be adjusted. When constructing this unit, $R5$ and $R6$ should be adjusted to about 28 ohms.

How it Works

When push-button S4 is pressed, a.c. power is applied to the unit. Diodes $D1$, $D2$, $D3$, and $D4$ rectify the 24 volts from the secondary of $T1$ and $C1$, $R1$, and $R2$ filter and d.c.-stabilize the resulting 24 volts. This voltage is fed through the timing network resistors, selected by "Set" switches S5 (0-.9) and S6 (0-9), to one of the two timing capacitors, $C4$ ("X1") or $C5$ ("X10"). Whichever capacitor is selected by switch S3 ("X1-X10") charges at its RC rate until a potential is reached that triggers $Q1$. When $Q1$ triggers, a pulse is produced at

Fig. 1. Schematic and parts list of timer discussed here.



R1,R4—1000 ohm, ½ W res.
R2—190 ohm, 2 W res.
R3—330 ohm, ½ W res.
R5,R6—500-ohm miniature pot
R7,R8—150,000 ohm, ½ W res.
R9,R11—50,000 ohm, ½ W res.
R10—100,000 ohm, ½ W res.
R12,R13—1.5 megohm, ½ W res.
R14,R16—500,000 ohm, ½ W res.
R15—1 megohm, ½ W res.
C1—500 μF, 50 V elec. capacitor
C2,C3—0.005 μF, 1600 V capacitor
C4—1 μF, 50 V elec. capacitor
C5—10 μF, 50 V elec. capacitor
D1,D2,D3.D4—50 p.i.v. diode (or HEP 175 full-wave bridge)
K1—4-pole, d.t., 24 V d.c. relay (2 poles used) (Guardian 200-24D and 200-M5)
T1—117 V trans., 24 V sec. (Triad F45X)
S1,S3—D.p.d.t. bat-handle switch
S2—S.p. normally closed push-button switch
S4—S.p. push-on, push-off switch
S5,S6—D.p. 10-pos., two-deck rotary switch
SO1,SO2—A.c. receptacle
Q1—300 mW unijunction transistor (HEP 310)
SCR1—800 mA, 30 V thyristor (HEP 320)

SWITCH POSITION	RESISTOR VALUE	
	S5	S6
0	0	0
1	50k	500k
2	100k	1M
3	150k	1.5M
4	200k	2M
5	250k	2.5M
6	300k	3M
7	350k	3.5M
8	400k	4M
9	450k	4.5M

Table 1. Resistor values corresponding to the S5 and S6 switch positions.

base 1 which is directly coupled to the gate of *SCR1*. *SCR1* then conducts allowing relay *K1* to energize. With *K1* energized, all voltage is removed from the timing network and *Q1*: this, then, is the circuit's stable condition.

When "Start" push-button *S2* is depressed, the current is removed from *K1* and the relay is de-energized, allowing current to flow through the timing network and *Q1*, starting another cycle.

Calibration

To calibrate the timer, an electric clock is plugged into one of the timer outlets (*SO1* or *SO2*) and used to measure the relay actuation time. The electric clock should be plugged into the socket where it is inoperative until push-button *S2* is pressed. Switch *S6* is set to 9, *S5* to .9, *S3* to "X1", and the timer actuated by pressing the "Start" push-button. If 9.9 seconds is not obtained, *R6* may be adjusted to set the correct time. (Note *R6* and *R5* will vary the timed sequence only slightly—if the timing is off, check *C4* and *C5*.) Set *S3* to "X10" and actuate the timer. If 99 seconds is not obtained, adjust the 500-ohm potentiometer *R5*.

If highly accurate timing is not needed, resistors *R7* through *R16* and switches *S5* and *S6* may be omitted and replaced by a 5-megohm potentiometer. The pot may be calibrated against the clock by marking graduations around the pot knob corresponding to the elapsed time shown by the clock.

With the relay de-energized, one of the two a.c. outlets is "on" and the other is "off." When the relay is energized, the outlet that was "off" is now "on" and *vice versa*. This switching action is also provided for manually by switch *S1* ("Focus-Time"). These outlets may be used to turn a safelight off while the enlarger is on, to facilitate focusing the enlarger, or in a timed chess match, one could use the *S1* switching arrangement to alternate the stopping and starting of two electric clocks or use the timed sequence to limit moves to a predetermined number of seconds. ▲

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Noise Filters in Hi-Fi

(Continued from page 44)

the noise curve lies above the program curve, we can see that this represents a somewhat "hissy" listening situation. The dashed line shows the effect of increasing program level by 7 dB, while noise remains constant. Now the full bandwidth can be used without the noise intruding. If necessary, the noise could be filtered out above 10 kHz without affecting the program.

To make things more difficult (and more realistic) in our example, let us assume that a 7-dB increase in level will produce intolerable distortion. This is really the basic dilemma in extending dynamic range—reducing noise while increasing undistorted signal level. Finite limits, both theoretical and practical, exist at both ends of the process. If we are limited to the solid-line program level, what can be done to reduce the noise with minimum effect on the signal?

Fig. 2 shows the results of using 6-dB/octave filters cutting off at 2 kHz and 6 kHz. Note that the 6-kHz filter removes only a small portion of the program's high-frequency content (which might not be very audible), but the 2-kHz filter removes a sizeable percentage of the program. However, in the latter case the noise is always below program level and a quiet background results. With the 6-kHz cut-off, some of the high-frequency noise will still be heard but at reduced intensity.

The relative effects on program and noise of these filters can be better appreciated by comparing the areas removed from the program and noise sections of the curves. The 2-kHz filter removes 22% of the total noise, but with it 30% of the program is lost. The 6-kHz filter has much less effect on both, but their order is reversed with 6% of the noise taken out together with only 2% of the program.

If we employ a steeper slope, such as 12 dB/octave, we find that the filtering effectiveness is greatly improved. Fig. 3 shows a 12-dB/octave filter, cutting off at 5 kHz. The loss of program is relatively small—only 8%—yet 27% of the noise has been removed. Although a 12-dB/octave filter is slightly more complex than a simple 6-dB/octave type, it would add little to the cost of an amplifier. Nevertheless, it is usually found in only the more expensive amplifiers and receivers.

Filter slopes can be increased greatly with more complex and costly circuitry. Some British amplifiers provide a choice of several cut-off frequencies, with adjustable slopes as great as 50 dB/octave! To illustrate how effective such a filter can be, we have included a 50-dB/octave characteristic, cutting off at 9 kHz, on Fig. 3. This filter removes 21% of the noise, almost as much as a 2-kHz, 6-dB/octave filter, but only 1.8% of the program is lost.

While these examples are contrived and the numbers may bear little relationship to subjective effects, anyone who has used a *good* filter appreciates its worth. Most of us have an understandable reluctance to use a filter that removes a third of the program, but it *is* possible to clean up a noisy or distorted program to a remarkable degree with a properly designed filter.

Low-Cut Filters for Rumble

Although hiss is usually the most annoying form of noise, problems can exist at the other end of the audio spectrum. Turntable rumble and hum, if they are audible, detract greatly from enjoyment of one's music system. Hum should be removed at its source—there is no excuse for filtering it out when a proper system installation will prevent it from occurring in the first place.

Rumble is another matter. Most good home record players are quite free from audible rumble under normal listening conditions. However, you may prefer to boost the bass, or listen at a high volume level, or both—and few turntables can claim to be completely rumble-free under those conditions. Even if *your* turntable can pass that test, many broadcast turntables cannot, and records often have "built-in" rumble.

Most rumble occurs at 30 Hz and below, but there may be considerable energy as high as 100 Hz. A simple 6-dB/octave cut-off below about 100 Hz can usually remove the objectionable sound with little or no audible effect on the program. Some amplifiers have rumble filters with 12-dB/octave slopes, beginning at about 50 to 80 Hz. They are more effective than simple filters, just as in the case of high-cut filters, but the difference is much less apparent to the ear. Not only do we usually have the assistance of loudspeakers with limited low-bass response, but our hearing is relatively insensitive to very low frequencies, as compared to our response to hiss. Then, too, it is rare to find program material with significant fundamental content below 50 Hz, so there is no sense of loss of program when the lower frequencies are removed. This is in sharp contrast to the situation existing with high-frequency noise.

When shopping for a receiver or amplifier, try the filters with various types of noisy program material. Weak stereo-FM broadcasts are an excellent source of "hissy" programs. Judge for yourself how effectively noise is removed and how much useful musical material is sacrificed in the process. ▲

Automatic Turntables

(Continued from page 30)

is calibrated from M (for single play) to 8, and is set to correspond to the number of records in the stack.

A unique feature of the 770H is the electro-chemical timer which shows the number of hours (up to 1000) that the turntable has been operated. When the turntable operates, current passes through the timer, which resembles a small thermometer 1⅝" long and ⅜" wide. A thin silver column darkens from one end as the turntable is used, with the end of the dark segment indicating the total operating time on a scale calibrated at 500 hours and 1000 hours.

The 770H has a somewhat heavier platter than other *Miracord* turntables, but is otherwise much like the 50H in features, operation, and construction.

Perpetuum-Ebner

Perpetuum-Ebner, whose higher priced automatic turntables were reviewed last June, now has lower priced models with a strong family resemblance to the 2038 and 2040.

The *P-E* 2035 has the same foolproof automatic indexing system as the more expensive models and in external features is virtually identical to the 2038. The most visible difference is its arm (which does not have the adjustable vertical stylus angle originally introduced by *P-E*), which is a light extrusion of "H" cross-section rather than a hollow cylindrical tube. The pivots and counterweight also differ from those of the higher priced models. It has a cast platter which we were unable to remove for weighing.

The anti-skating correction of the 2035 is coupled to its tracking-force adjustment (this is the same arrangement used by the competitively priced *Dual* 1215). Changing the stylus force automatically adjusts the anti-skating force to the appropriate value. The change cycle of the 2035 required 17.5 seconds.

The lower priced 2010 has the versatile single-lever operating control of its deluxe relatives, with a well-damped cueing system. It is fitted with a light drawn turntable platter and has an unbalanced tonearm with no anti-skating compensation.

Dual

Although we did not test any *Dual* players for this report, we are informed that the model 1212 of last year's survey has been replaced by the 1215. The 1215 is mechanically similar to the 1212, but has been re-designed to match the styling and control layout of the company's 1209 and 1219. The arm counterbalance is also now a vernier-adjustable type instead of the sliding and locking type of the 1212.

Price Versus Performance

Our conclusions from this year's follow-up survey of automatic turntables are much the same as last year's. In the lower priced units—under about $75—the arm is usually unbalanced (which requires careful turntable leveling), uncompensated for skating force, and has enough bearing friction to require the use of tracking forces of 2 to 4 grams. The platter is relatively light, of drawn construction, and driven by a four-pole induction motor (some lower priced *Garrard* units have the "Synchro-Lab" motor, which has the constant-speed characteristics of a synchronous motor).

Between $75 and $100, most tonearms are balanced and have low enough friction for reliable operation at 2 grams (and sometimes as low as 1 gram). Most of the platters are castings, weighing several pounds. Although rumble, wow, and flutter tend to be lower in this group than in the lower priced models, there are numerous exceptions to this rule. Vernier speed adjustments are found on some players in this price range.

As before, we have concluded that the $100 to $130 price range offers the best combination of performance and economy. Record players in this range can be audibly superior to less expensive models—if they are fitted with high-quality cartridges that could not be used at the higher tracking forces required by the arms in lower priced units. They also have more convenience features and generally smoother handling characteristics.

Higher prices bring more refinements and special features, but, in our experience, rarely any tangible improvement in performance. The rumble, wow, and flutter of these players, which sell for up to $200 and more, may be measurably lower than those of lower priced models—but they also may not. In no case that we have encountered could these differences be heard. However, there is no denying the convenience of a built-in stroboscope, a smooth and drift-free cueing device, a stylus timer, or an arm that can operate at the minimum force of any presently available cartridge, or any that are likely to come along in the next few years. More accurate anti-skating compensation and adjustable vertical tracking angle can make a minor improvement in measured performance and, in special circumstances, could give an audible advantage. It is this ultimate refinement of excellence that the various manufacturers offer in their premium-priced record players, rather than any immediately obvious or audible advantage. ▲

NEW PRODUCTS & LITERATURE

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

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

POWER-SUPPLY CONSOLE

The Model 1106 power-supply console provides low-cost, multiple-channel requirements in as many as three high-voltage outputs, each independently adjustable. The basic unit provides regulated low voltage to accommodate one Model 1120 amplifier/discriminator, and may be expanded to provide three low-voltage outputs on standard mating connectors. It also includes push-button control for high-voltage metering and front-panel high-voltage adjustments. Separate rear-panel controls provide for upper limit safety set on each high-voltage output.

A technical brochure on the Model 1106 is available on request. SSR Instruments

Circle No. 3 on Reader Service Page

STEREO-FM RECEIVER

A stereo-FM receiver, with a power output (IHF) of 80 watts at 4 ohms, and 58 watts at 8 ohms has just been introduced as the KR-4130. The unit can drive two sets of stereo speakers and its frequency response is 20-40,000 Hz ±1.5 dB.

The tuner section has two FET's and a 4-gang tuning capacitor in the front-end and two IC i.f. stages for good selectivity and capture ratio.

The controls are well organized and their functions clearly marked: step-type tone controls for bass and treble; speaker selector switch for speakers A, B, A + B, plus stereo headphones; mode selector for FM, phono, or auxiliary; and push-buttons for tape play/monitor, stereo/mono mode, noise filter, and loudness. Kenwood

Circle No. 4 on Reader Service Page

MARINE INTERCOM/HAILER

A marine electronic intercom/hailer kit which permits boaters to talk or listen to other boaters in the area, talk or listen for docking instructions, and talk or listen to persons handling mooring lines has been introduced as the "Airex of Ohio" Model H1-10.

The kit includes a master control unit, weatherproof horn speakers with adjustable tilt bracket, and necessary wire and mounting hardware. An accessory speaker for mounting inside the cabinet is an optional extra. The control unit features a built-in microphone, with lock-to-talk switch that frees the skipper's hand for control of the craft during docking operations. Another switch lets him use the outside horn speaker, the optional inside speaker, or both.

Operating off a 12-volt battery, the unit features a high-gain transistor amplifier circuit with 500-mA maximum current consumption. S & A Electronics

Circle No. 5 on Reader Service Page

CASSETTE/CARTRIDGE ADAPTER

A new adapter that allows stereo cassette tapes to be played on 8-track cartridge players is now available as the Muradapter. This new unit eliminates the need to have separate sets of tapes for home and auto listening. Any standard cassette can be played through any 8-track car stereo system.

The adapter is geared to simple one-hand operation and poses no problem to the operator of the automobile. It is inserted in exactly the same manner as any 8-track cartridge and the preamplifier switches on automatically upon insertion. To turn the adapter off, the unit is pulled out two inches in the same way a cartridge is removed. Mura Corp.

Circle No. 6 on Reader Service Page

STEREO TAPE DECK

The T-6600 stereo tape deck has been designed for continuous operation in home hi-fi systems and features a precision hysteresis-synchronous motor for constant-speed operation even under conditions of line-voltage fluctuations.

The deck has a signal-to-noise ratio in excess of 55 dB; frequency response of 30-20,000 Hz at 7½ in/s and 30-13,000 Hz at 3¾ in/s; and provides 4-track, 2-channel stereo or 4-track mono operation. Wow and flutter is less than 0.12% at 7½ in/s.

The circuit contains 18 semiconductors—14 transistors and 4 diodes. It will drive tape reels up to and including 7 inches. Pioneer

Circle No. 7 on Reader Service Page

STANDARD-TIME RECEIVER

The Model STR-1 receiver is a compact unit which receives continuous standard-time and standard-frequency broadcasts from WWV on 5, 10, and 15 MHz. Optional coverage is also available for Canadian standard-time broadcasts from CHU on 7.335 and 14.670 MHz.

The unit can be used by industrial labs, radio and television stations, two-way radio service centers, radio hams, astronomers, boating and sports-car enthusiasts, as well as others interested in accurate time or frequency.

Operation is simplified with a volume control/on-off switch and a channel-selector switch on the front panel. A choice of three frequencies assures virtual 24-hour reception anywhere in the United States, according to the manufacturer.

Sensitivity is 0.25 microvolt for 10 dB signal-plus-noise/noise ratio. Two dual-gate MOSFET's are used in the front-end to achieve high sensitivity, low noise, and good a.g.c. characteristics. A built-in 24-inch telescoping antenna is all that is needed for reception in most areas. A jack on the back panel is provided for an external antenna, if required.

A data sheet, complete with technical specifications and schematic diagram, is available on request. Caringella

Circle No. 8 on Reader Service Page

HIGH-ENERGY TAPE

The new Scotch brand "High Energy" tape is designed to bring the fidelity of reel-to-reel sound tape to cassettes, according to the company. The new cassette is based on a proprietary cobalt-modified ferric-oxide formulation and features such characteristics as universal compatibility, long tape wearability, and minimum recorder head wear, according to its maker. It is said to produce a greater undistorted output at all frequencies and show an improvement in dynamic range from 2 dB at low frequencies to 6 dB at the high end. The tape operates at standard low-noise bias and equalization levels, making it fully compatible with existing and envisioned equipment. 3M

Circle No. 9 on Reader Service Page

AM/STEREO-FM RECEIVER

A medium-power AM/stereo-FM receiver has recently been introduced as the Model 1000X. Although it does not have the output of professional units, it does offer 100 watts of IHF music power—enough to drive low-efficiency speaker systems or a pair of speaker systems simultaneously. This output is combined with a sensitive 2-μV low-distortion stereo-FM tuner that uses an FET in the front end.

In addition, the receiver features wide-dial linear-scale tuning, FM muting, a signal-strength meter, two tape-monitor circuits for copying and dubbing, independent preamps and power amps for easy insertion of electronic crossovers and other accessory equipment, automatic stereo/mono switching, and independent bass and treble boost and cut tone controls. It comes complete with an enclosure of American walnut. Sansui

Circle No. 10 on Reader Service Page

COUNTER SYSTEM

A mainframe plus a choice of four functional snap-in modules, including a 500-MHz counter and an unusual battery pack, are the elements of a new six-digit electronic counter which is being introduced as the Model 5300A measurement system.

Autoranging, serial BCD digital output, and a high-stability crystal reference oscillator, unusual in low-cost counters, are standard with this model. This state-of-the-art system includes MOS/LSI and super-speed bipolar integrated circuits, solid-state LED displays, thin-film hybrid IC's, read-only memories, among other features.

All of the functional modules mate with the same 5300A mainframe and include the Model 5301A 10-MHz frequency counter; the Model 5302A 50-MHz universal timer/counter with period, ratio, and totalizing functions as well as frequency and time interval; the Model 5303A 500-MHz frequency counter; and the Model 5304A 10-MHz timer/counter with 100-nanosecond time-interval resolution and period average function in addition to frequency. Hewlett-Packard

Circle No. 11 on Reader Service Page

SPEAKER SYSTEM

The new Citation Thirteen omnidirectional speaker system incorporates unique speaker cones and a novel method of mounting the drivers in the top section of the baffle to achieve multidirectional sound distribution in all planes. All of the drivers are fastened to a mounting board which is tilted 14 degrees off the horizontal plane. This equalizes transit time at the mid- and high frequencies and produces a blending of

direct and reflected sound for proper spatial representation of instrument placement in the orchestra, according to the manufacturer.

Three seven-inch low-frequency drivers are loaded by a double-chambered enclosure which loads bass response down to 30 Hz without doubling. By tuning the double chambers an octave apart, the higher frequency creates acoustic loading in the middle bass region while the lower frequency maintains loading down to a suitable low-frequency limit.

The system is housed in a contemporary enclosure of hand-rubbed walnut. A choice of grille cloths to cover the top panel is provided. Harman-Kardon

Circle No. 12 on Reader Service Page

EIGHT-TRACK DECK

A new eight-track tape cartridge player deck, of all-silicon solid-state design, has been introduced as the SP.

The stereo deck features fine-tuning track-adjust control which helps eliminate noise and channel crosstalk. This Micro Balance feature insures perfect alignment between the tape and the playback head, providing full tape frequency response and a signal-to-noise ratio of better than 45 dB, even for tapes that are mistracked, according to the company.

A hysteresis-synchronous motor feeds the tapes at a constant 3¾ in/s. This speed accuracy minimizes wow and flutter, which measures 0.25%. The motor automatically advances the tapes in sequence through their four pairs of stereo tracks. A channel indicator shows which tracks are being played at any time, and a selector switch permits the user to change channels at a touch. Bogen

Circle No. 13 on Reader Service Page

STEREO MUSIC CENTER

The new Model S-4100 stereo music center incorporates an AM-FM tuner, full-feature pre-

amplifier, a 100-watt (±1 dB) stereo amplifier (25 + 25 watts r.m.s. per channel at 8 ohms), a 4-speed automatic turntable featuring cueing and anti-skate control, a Shure magnetic stereo cartridge with diamond stylus, and a molded vinyl dust cover. The entire unit is housed in an oiled-walnut case.

The music center comes without speakers, allowing the user to select his own speaker systems. The S-4100 will drive low-efficiency speakers. Sherwood

Circle No. 14 on Reader Service Page

DROP-PROOFED V.O.M.'S

A new line of rugged v.o.m.'s, currently offered in five models, has been introduced as the Model 660 series.

The new meters are "drop-proofed" and are warranted in writing to work after accidentally being dropped five feet. They use a rugged taut-band mechanism and are housed in high-impact plastic cases. In addition, the units have diode-protected meter movements, temperature compensation, pluggable circuit board assemblies, can be re-fused externally, recalibrated without removal from the case, and have special calibrated scales for dB measurements.

The instruments currently available include the Models 660, 661, 662, 663, and 666 v.o.m.'s. Complete specifications are available on request. Weston

Circle No. 15 on Reader Service Page

STEREO TAPE DECK

The GH-500D stereo tape deck features record and play heads of pure crystal ferrite and glass which the company claims are virtually indestructible due to their high degree of hardness. In addition, they repel dust even in conditions of high humidity as well as allow com-

pletely stable head-to-tape recording and playback characteristics, according to the company.

The deck includes automatic continuous reverse; automatic level control; a magnetic braking system; a pause/edit button for remote operation; three motors; four tape speeds; tape lifter; automatic shut-off/stop; an electrical track selector; and sound-on-sound, sound-with-sound mixing.

A data sheet with complete electrical specifications is available on request. Roberts

Circle No. 16 on Reader Service Page

INDUSTRIAL ANALYZER

A new portable industrial maintenance analyzer consisting of seven basic analyzing devices and accessories is being marketed as the Model 990.

This "Maintenance in a Case" set consists of a Model 900 v.o.m. with a special dial for temperature, decibel, and r/min ranges; a hand-held Model 901 tachometer-generator; temperature probe; Model 10 clamp-on a.c. ammeter adapter; Model 101 line separator; Model 611 leads used with the Model 10; a high d.c.-current shunt; all housed in a molded high-impact black plastic carrying case with die-cut foam inserts for storing and protecting the equipment. The case measures 12" × 17" × 4½" and weighs 10 pounds with equipment. Triplett

Circle No. 17 on Reader Service Page

RECORDING TAPES

A new line of low-noise, high-ouput recording tapes has just been introduced. Included are 5-inch reels in 600, 900, and 1200 foot lengths; 7-inch reels with 1200, 1800, 2400 feet of tape, and cassettes in 30, 60, 90, and 120 minute lengths. Both low-noise, high-output and chromium dioxide cassette tapes are available.

Data sheets covering recording, magnetic, and physical properties on each of the types are available on request. Memorex

Circle No. 18 on Reader Service Page

STEREO AMPLIFIER

The KA-7002 stereo amplifier is a new top-of-the-line model which features direct coupling

and a complementary-symmetry driver stage to provide 196 watts (IHF) of stereo sound.

The new unit also features an exclusive low-level phono input (0.06 mV) for moving-coil type or low-level output cartridges; Phono 1 input impedance selector; a null balance switch to test for stereo balance of left and right channels; a tone-control switch that selects bass or treble turnover frequency; and provisions for 4-channel stereo.

Power output is 196 watts at 4 ohms, 170 watts at 8 ohms, and continuous power output (r.m.s.) 100 watts or 50 watts per channel with both channels operating simultaneously with 8-ohm load at any frequency from 20-20,000 Hz. Kenwood

Circle No. 19 on Reader Service Page

SOLID-STATE SUPPLIES

Four solid-state regulated power supplies which incorporate a short-circuit protection feature are being introduced as the WP-700A, WP-702A, WP-703A, and WP-704A. The WP-700A and 702A are indentical except that the latter is a dual unit. Both power supplies have regulated output voltage levels that are continuously adjustable from 0 to 20 volts, at current levels up to 200 mA. The WP-703 has a regulated output voltage that is continuously adjustable from 0 to 20 volts at current levels up to 500 mA while the

WP-704 is adjustable up to 40 volts at current levels up to 250 mA.

Complete technical specifications on these new supplies are available on request. RCA Commercial Engineering

Circle No. 20 on Reader Service Page

SPEAKER LINE TESTER

The Raymer Model LTS-1 is a self-contained, a.c.-powered, direct-reading instrument designed for fast determination of: wattage requirement of any 25- or 70-volt speaker line up to 200 watts; the wattage drawn by a speaker with a 25- or 70-volt transformer; and the impedance of the voice coil. A three-position slide switch is provided for the proper selection and measurement of the 25-volt line, 70-volt line, or speaker voice coil. A sensitive meter is used to indicate null.

In addition to testing for wattage, the unit also tests for shorts and opens, and determines whether the line is for 25 or 70 volts.

The instrument is housed in a compact, high-impact plastic case measuring 6¼" × 3¾" × 2" with a tilt handle for carrying. Trutone Electronics

Circle No. 21 on Reader Service Page

METAL CASSETTE

The CM Series digital metal cassette for which all parts and tape are assembled in a clean room is now on the market. The series meets Federal Specs. 209a and is free from contamination, according to the company.

The low-cost metal digital cassette acts as a ground which eliminates the static charge problems developed in plastic cassettes. A certified premium digital oxide tape is used when assembling the cassette, then is recertified in the cassette, and sealed in a re-usable plastic bag before leaving the clean room. The new cassette will fit any standard cassette machine.

For OEM users, the CM Series cassette is available with special leaders, in different lengths, thicknesses, and magnetic coatings. Auricord

Circle No. 22 on Reader Service Page

FM DIGITAL TUNER

The Mark VI FM tuner features a digital-readout tuning section with four Nixie indicators to identify the exact station frequency for any of the 100 FM channels available. The readout is crystal-controlled which offers the same degree of accuracy as required by the FCC for operation of FM stations. The readout count is corrected 60 times per second, allowing fast dialing across the band. Since the conventional dial scale and pointer are unnecessary, the usual dial-string assembly is eliminated.

Also featured is a high-intensity 3" rectangular scope. The display on the scope indicates the

presence of multipath distortion, center-of-channel tuning, relative signal strength, and display of all stereo or mono signals.

Technical specifications on the Mark VI are available on request. SAE

Circle No. 23 on Reader Service Page

AUTOMATIC TURNTABLES

A new line of three-speed automatic turntables has just been introduced as the Models 502, 402, and 302. All three models features extremely low wow, flutter, and rumble, according to the company, and will accept a full range of cartridges, tracking with a stylus pressure as low as one gram or less.

The operating functions of manual start, stop, and reject/autostart are controlled by a single lever. All units have variable anti-skating compensation and a cue control that sets the stylus down on the precise groove selected. The cue control is viscous damped so the arm descends gently to the record surface. All three units have a pitch control that allows the user to vary the speed of the record ±3%. In addition, all have a special safety oriented sensing device that not only senses the size of the record but prevents the stylus from descending onto an empty platter.

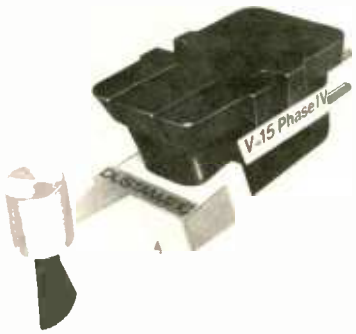
The Model 502 features vertical tracking-angle adjustment and has a 7.1 pound platter and a heavy-duty, four-pole motor; the Model 402 is the same except that the platter is a four-pound unit, while the least expensive Model 302 is similar to the other units except that its wow, flutter, and rumble content are marginally higher. Its tonearm is of the girder-beam type instead of tubular. Fisher

Circle No. 24 on Reader Service Page

STEREO CARTRIDGES

Two new models have been added to the V-15 Phase IV "Micromagnetic" series of stereo cartridges, the V-15 Phase IV-AT and ATE.

The Phase IV line features a new "keystone" mounting adapter which permits simple installation. Each model incorporates a replaceable V-Guard floating stylus with Dustamatic brush. The stylus system is newly redesigned to provide lower moving mass for better frequency response and greater tracking ability, according to the company. Pickering



Circle No. 25 on Reader Service Page

PORTABLE P.A. SYSTEM

A new portable p.a. system which features a hand-held FM wireless microphone and a speaker/amplifier has been introduced as the WA-100. The system operates on either 117 V a.c. or batteries. Audio output is 10 watts when a.c.-operated and 5 watts when battery powered. The amplifier will operate on either 40.68 MHz or 47.27 MHz. It has a microphone storage compartment with built-in charger.

The amplifier/speaker is housed in a compact, leather-finished wood cabinet with convenient carrying handle and weighs only 14 pounds, 2 ounces without batteries. It measures 14" w. × 12" h. × 5" d. Fanon

Circle No. 26 on Reader Service Page

SCANNING RECEIVER

The "Tri-Bander" is a scanning receiver which sequentially scans low-band, high-band, and u.h.f. frequencies. It is capable of monitoring up to 16 channels. When shipped, it is programmed to receive 8 high-band, 4 low-band, and 4 u.h.f. frequencies. However, the user can reprogram the unit to monitor any combination of frequencies without adding to or changing any PC boards or modules.

Rate of scan can be adjusted from ½ second per channel to 150 channels per second. As the scanning circuit samples each active channel, the channel number is displayed on a digital readout tube.

The unit operates on both 117 V a.c. and 12 V d.c. Cords are supplied for both voltages. Mounting brackets are available for mobile installation. Kris

Circle No. 27 on Reader Service Page

MANUFACTURERS' LITERATURE

SHORT-FORM CATALOGUE

A new 1971 short-form catalogue containing more than 4000 product listings, any one of which can be located in only a few seconds through a unique numerical-alphabetical index, has just been issued by Switchcraft, Inc., 5555 N. Elston Ave., Chicago, Illinois 60630.

The new indexing concept is of particular help to representatives and distributors of the firm's products because they can locate essential data regarding any product, including prices, while talking with buyers on the phone.

The 36-page catalogue covers such major product categories as jacks, plugs, switches, connectors, molded cable assemblies, and audio accessories.

TRAINING-PROGRAM REPORT

A 76-page technical report (70-19) entitled "Development of a Training Program and Job Aids for Maintenance of Electronic Communication Equipment" by Richard M. Gebhard and prepared by the Human Resources Research Organization for the Department of the Army has now been released for public distribution.

The training program at the Southeastern Signal Corps School at Fort Gordon, Georgia was studied and an analysis made of existing electronic communication equipment and applied to the ten items of equipment maintained by carrier equipment repairmen. Job aids were developed along with a course of instruction that was 420 academic hours as against the standard 856-hour course for the same job. Graduates of both "Jobtrain" and the conventional course were tested on troubleshooting 18 malfunctions placed in the items of equipment. They were also tested on their ability to align, remove, replace, name, locate, and make final tests on the equipment. This report details the results.

For details on obtaining a copy of this publication, write Human Resources Research Organization, 300 North Washington Street, Alexandria, Va. 22314.

TUNER SPRAY DATA

A six-page, four-color brochure describing the properties of "Tun-O-Brite," a heavy-duty tuner spray with 3-way action, is now available for distribution.

The new spray cleans away residue, dirt, and corrosion and polishes the tuner contacts without scratching delicate plating, then lubricates the contacts for smooth operation. Chemtronics

Circle No. 28 on Reader Service Page

MEDIUM-POWER RECTIFIERS

A comprehensive semiconductor catalogue which cross-references more than 400 medium-power rectifiers by performance rating and by JEDEC and industrial-type number has been issued by the Semiconductor Division of Westinghouse.

The catalogue covers a full line of 3- to 70-ampere, stud-mount rectifiers. Index letters, keyed to a matrix of performance ranges in the catalogue, allow design engineers to pick the ratings needed, then focus on specific products and specify by type number. Alternatively, purchasing executives and maintenance engineers can locate device specifications by looking up the rectifier's JEDEC or industrial-type number in the appropriate alphanumeric indexes in the catalogue.

Letterhead requests for copies of Catalogue 54-100 should be addressed to John DeFazio, Marketing Services Manager, Semiconductor Division, Westinghouse Electric Corp., Youngwood, Pa. 15697.

STANDARDS CATALOGUE

The American National Standards Institute, 1430 Broadway, New York, New York 10018 has announced publication of its 1971 catalogue which lists 3942 American National Standards and 1837 international recommendations, and includes a 21-page index to the titles of all listings.

This new 128-page edition includes all American standards approved by ANSI during 1970, as well as international recommendations (standards) received last year from the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC), the International Commission on Rules for the Approval of Electrical Equipment (CEE), and the Pan American Standards Commission (COPANT).

MARINE ELECTRONICS

Thirty-one marine electronics aids for navigation, communications, and safety are pictured and described in a new 20-page color brochure which is now available for the asking.

The full line of products for pleasure boats and small commercial vessels includes indicating and recording Fathometer depth sounders; radars; v.h.f./FM SSB, CB, and AM radiotelephones; direction finders; loran receivers; loud hailers; and accessories. Raytheon

Circle No. 29 on Reader Service Page

TEST INSTRUMENT CATALOGUE

A 20-page, multicolor catalogue which lists and illustrates more than 50 test instruments and accessories for electronics equipment maintenance, repair, and servicing is now ready for distribution.

The catalogue features five digital-clock binary-countdown color-bar pattern generators including a battery operated, portable instrument that will fit into a tube caddy; a number of solid-state oscilloscopes/vectorscopes including a new 3" portable triggered scope and a 5" unit; a sweep marker; voltmeters; FET multimeters; field-strength meter and CRT high-voltage probe and meter; transistor checker/tracers; grid-dip meters; and various accessories. Leader Instruments

Circle No. 30 on Reader Service Page

PHOTOCONDUCTIVE CELLS

Bulletin PCD-6 listing a complete line of photoconductive cells has just been published.

The brochure provides details on both plastic coated and hermetically sealed cells. The 4-page, two-color folder provides information on the five types of material from which the devices are made: CdS, CdSe, and modifications of the two formulations. Technical data includes curves and tables indicating response in relation to time, illumination, and temperature for each of the five types. Vactec

Circle No. 31 on Reader Service Page

TV SERVICING AIDS

A six-page, two-color brochure entitled "Successful Servicing in 1971" outlines a new selection of television service and promotional aids

designed to help a service technician create goodwill among his customers.

These aids include a color-TV service handbook, mobile test equipment table, TV service mirror, picture tube mat, "by-stage" receiving tube and semiconductor guide to color-TV receivers, a picture-tube product guide, as well as numerous items to help in running a service business and in promoting these services to potential customers. In addition, a number of goodwill gift items are also available on the program. RCA Electronic Components

Circle No. 32 on Reader Service Page

TEST EQUIPMENT

A 16-page, two-color brochure which lists an extensive line of test equipment for electronics maintenance men and service technicians has just been published.

Included in the catalogue are pictures and complete specifications on an extensive test-equipment line which embraces multimeters, tube testers, CRT testers, TV sweep-circuit analyzers, transistor and FET testers, sweep and marker generators, a d.c. bias supply, color-bar generators, power monitors, field-strength meters, component substitution boxes, transistor-radio battery eliminators, filament checkers, and dual-purpose oscilloscope/vectorscopes. Sencore

Circle No. 33 on Reader Service Page

TRANSISTOR CHARTS

A series of selector charts which permit the user to specify virtually all mechanical and electronic characteristics of a required transistor have been released.

The firm stocks standard transistors but has arranged a large part of its production around custom units supplied at stock prices. Four such charts are presently available, two covering high-power and two low-power transistors. To determine the proper chart for a certain requirement, the user chooses the power level and, as a second parameter, the power dissipation rating. Maximum ratings are 4 watts and 20 watts in the low-power versions and 60 and 200 watts in the high power. Semicoa

Circle No. 34 on Reader Service Page

STEREO ACCESSORIES

A comprehensive product line of car stereo and radio accessories are featured in a new 8-page, 3-color brochure, No. FR-132.

The new Audiotex accessory line includes cartridge radio tuners and burglar alarms, power supplies that permit use of 12-volt automotive equipment at home, transverters for using small battery/transistor equipment in a car, speakers, controls, grilles, tape accessories, and other audio products. GC Electronics

Circle No. 35 on Reader Service Page

DIGITAL PANEL METERS

A six-page, two-color catalogue featuring a full line of low-cost, 2, $2\frac{1}{2}$, $2\frac{3}{4}$, 3, and $3\frac{1}{2}$ digit digital panel meters for use in production and general testing, electrical and electronic testing, educational and other OEM applications is now available.

The catalogue not only provides complete electrical, physical, and mounting specifications but also includes a comprehensive specification selection guide and prices subject to quantity discounts. The guide is valuable in determining the proper digital panel meter for the OEM application being considered. Triplett

Circle No. 36 on Reader Service Page

LOGIC ELEMENTS

Signetics Corporation, 811 E. Arques Ave., Sunnyvale, California 94086 has announced publication of Vol. 1 of its "DCL" Specifications Handbook covering logic elements.

The "Designer's Choice Logic" handbook clearly explains the performance and use of the Series 8000 family. This volume covers basic logic elements including multivibrators, low-power elements, high-speed elements, ultra-high-speed elements, and interface elements.

The handbook is divided into five sections for each reference and covers: design considerations, electrical characteristics, a.c. testing, applications, and information on the company's "Sure" program. The handbook is lavishly illustrated throughout.

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65 (bottom)	Henry Mann, Inc.

CMOS Logic

(Continued from page 43)

ble voltage difference, unlike other types of integrated circuits.

The *nor* gate discussed above is but one element of *RCA*'s line. All the standard digital circuits are available off-the-shelf including flip-flops, CMOS to T^2L interface circuits, non-destructive readout memories, inverters, static registers (both parallel-to-serial and serial-to-parallel), decade counters with decimal decoder, pre-settable divide-by-*n* counter, select gates, analog/digital switches, and a 14-stage ripple counter.

Other Manufacturers

Among major semiconductor manufacturers, *Motorola* has also entered the CMOS device market and offers gates and flip-flops. Other circuit types are under development and will become available if the market reaches the potential now expected.

At least two small companies, *Ragen Semiconductor* of Whippany, N.J. and *Solid-State Scientific* of Montgomeryville, Pa., are also actively working with CMOS structures. Although primarily engaged in custom LSI work, both of these manufacturers have some digital circuits in their ready-built lines.

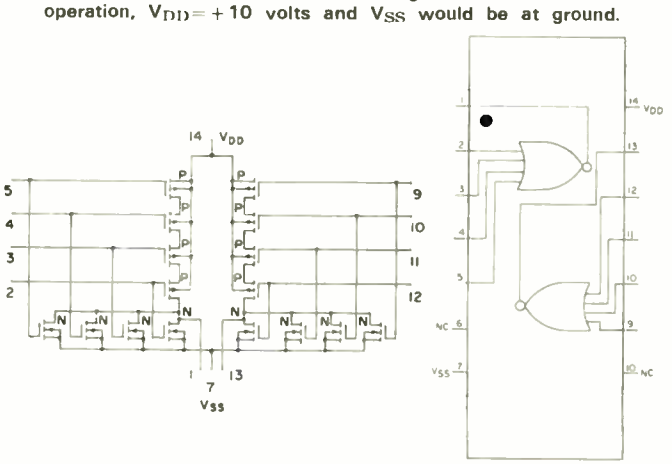
Ragen recently (May, 1970) announced a 64-bit shift register with clock rates up to 25 MHz. The CMOS chip also contains control logic for the data shifting operation, reducing the need for additional control circuitry.

While the pricing of individual CMOS logic circuits is not yet generally competitive with such popular, high-sales-volume lines as T^2L, there are no technical reasons why CMOS prices cannot be reduced. Based on the history of the semiconductor industry, as sales volume increases, prices tend to decrease. A more brisk competitive atmosphere has also forced a downward price trend in the past.

In the area of medium- and large-scale integrated circuit arrays, CMOS appears destined to play a major role. With single power-supply operation and extremely low standby power, CMOS arrays appear more suitable than the conventional *p*-MOS circuits.

But it is in the small, very-low-power, battery-operated instruments that CMOS should create the most interest. Using CMOS arrays, *Hamilton Watch* has produced a prototype crystal-oscillator-driven, digital-readout wristwatch. Other designs are sure to follow, along with instruments and systems that were once impractical because of complexity, cost, and power drain. Indeed, CMOS circuits may well provide the most important development in semiconductors for the decade of the seventies. ▲

Fig. 5. (Left) Schematic and (right) logic diagrams of RCA's commercially available CMOS "nor" gate unit CD4002. In operation, $V_{DD} = +10$ volts and V_{SS} would be at ground.



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