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Psychology of Pay TV

Pay television, or subscription TV as the FCC calls it. Service technicians fear it, so their associations fight it. Theater owners see it as a threat to their own prosperity, so they battle it viciously. City councils use it as a reason for blocking CATV franchises. Until recently, Hollywood film producers viewed it suspiciously, torn between attractive fees offered by pay TV and possible loss of theater outlets if top films were sold for first-run showing on pay TV.

On the other hand, much of the bickering about pay TV has to do with the viewers. Proponents insist that audiences will gladly pay to watch high-quality movies uninterrupted by commercials. Opponents argue that viewers are unlikely to pay extra for TV entertainment they can now have “for free.” Pay-TV companies say the experiment that has been going on in Hartford, Conn., for the last 4 years proves customers will pay; opponents claim just as seriously that the Hartford experiment proves they won’t.

It isn’t likely there will ever be any actual agreement on any of these points. Like CATV, pay TV will live or die according to whether or not the viewers actually do want it. If they don’t, pay TV will have been just another temporary fancy.

There are, however, some questions about pay TV, about certain psychological aspects of the medium, that are worth looking into. These psychological factors themselves generate arguments, but they should be considered in any thorough evaluation of pay TV.

One factor is the “pay for it and it’s better” syndrome, based on the assumption that no one appreciates anything that is free. Viewers therefore disparage the quality of programs they now get on TV (while watching them insatiably), call the commercials lousy, and grumble that TV is the country’s great time-waster. Question: Would they think the fare was better if they were paying for it directly?

Viewing habits will be important to final acceptance of pay TV. Through the last 15 years, TV audiences have grown accustomed to breaks for commercials. They use the time to pour another beer, eat a snack or two, or pop some popcorn. Some simply stretch and relax from the wearying tension of continuous TV-watching. With this rest-period habit now well formed, how many long-time TV owners sit in a movie theater uneasily and restlessly (though perhaps unconsciously) waiting for the commercial breaks they know aren’t coming? Children (and—face it—some adults) enjoy commercials. Question: Will 15 years of seeing commercials in regular break-spots be brushed aside in favor of 1 1/2- and 2-hour uninterrupted programs?

Cable TV (CATV) is another factor, despite its owners’ disclaimers. Though aired pay TV is practical, it is easier to pipe pay-TV programs down the community wire. CATV customers get a bill each month anyway, the reasoning might go, so a few extra dollars for special programs would be hardly noticeable. Question: Will CATV subscribers pay this added cost when they already pay a monthly fee for their TV enjoyment?

First-run movies have already come to ordinary TV. In a recent week, there were eight movies under 4 years old, six of them in color; there were also nearly two dozen popular ones from the 1950’s. Recent top theater attractions are even now being bought up by the three TV networks. Question: With top-grade movies available on “free” TV soon after (or even before) their release to theaters, will viewers spend money to see similar fare on pay TV?

In last month’s editorial, I pointed out the extremely low cost of owning a TV receiver. This cost is necessary no matter what the program source, so the pay-TV fee is simply extra. Question: Will viewers pay twice (CATV viewers three times) to watch top-grade programs on TV?

The answers to all these questions haven’t yet been determined. Time alone will tell. But they and many others will have to be answered before pay TV becomes the rule rather than the experimental exception.
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FIRST SOLID-STATE TV CAMERA PICKUP "TUBE"

Semiconductors invaded one of the last few pockets of vacuum-tube domain recently. A substitute for the conventional TV camera pickup tube has been built by RCA. The sensing device consists of four glass slides, each an inch square, which contain networks of 132,000 thin-film elements. Light from the scene falls on an area containing 32,400 microscopic dots of photoconductive material.

The supporting circuitry includes 540 thin-film transistors, which are used for horizontal and vertical scanning of the image, as well as other control functions.

The camera—completely solid-state and containing a transmitter and antenna—is shown in the photo being held by its developer, Dr. Paul K. Weimer. He says the organization and readout of the photoconductive dots in the sensing array are much like the readout of a standard computer memory. Hence it’s possible to send pictures from the camera directly to a computer for processing or storage.

ELECTRIC BIKE

With GM and Ford working on developmental models of electric-powered automobiles and trucks, it remained only for somebody to come up with a battery-driven motorcycle. Union Carbide Corp. has done just that. The motorbike, which was demonstrated recently in New York City, uses a fuel-cell battery which obtains its energy from hydrazine fuel, and oxygen drawn from the air. The vehicle can run over 200 miles on a gallon of fuel, and has a top speed of 25 mph.

Electric-powered vehicles are viewed by many as a partial solution to the urban air-pollution problem. The electric bike is not only fumeless, but occupies little space, thus reducing traffic congestion, too.

JACK BEEVER DEAD AT 51

A fatal heart attack felled one of the electronics industry’s most widely talented and well known engineers.

Jack Beever was a pioneer in the CATV, MATV, and ETV fields. Though only a high-school graduate, he had educated himself sufficiently to develop electronic medical equipment, such as X-ray and EKG gear. He engineered large parabolic antennas, played piano and organ, and was an expert on sound reproduction.

He served as a member of the Presidential Advisory Committee to the FCC for the development of all-channel broadcasting. Later, he was director of the FCC tests in New York City to determine the feasibility of UHF in metropolitan areas.

Beever was the author of more than 50 published technical articles and papers, as well as several books. At his death (last November 25) he was technical director of Jerrold Electronics Corp.

FAST-FORWARD CAR TAPE

Sometime in 1967, automobile cartridge-tape players will be available with a fast-forward speed. This feature will do much to enhance the popularity of taped music in cars, as a listener can select the musical number he wants, skipping others.

The fast forward feature appears on both mono and stereo units produced by Lear Stereo Division, Lear Jet Corp.

WHAT HAPPENED TO THE 21-INCH TV?

It’s still around, but now they call it “a 212-square-inch picture.” The change in definition is due to a ruling, effective January 1, 1967, by the Federal Trade Commission. The regula-
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The tiny devices are even finding their way into stereo hi-fi equipment. H. H. Scott is producing three stereo FM receivers with IC's in the i.f. strip (see photo). Fisher Radio Corp. plans to bring out an AM-FM receiver using integrated circuits.

Motorola employs IC's in an FM transceiver they make for the Army.

For more detailed information on integrated circuits, be sure to see the March 1967 special issue of RADIO-ELECTRONICS.

MORE ON LASERS

High-voltage and high-power circuits may now be switched more easily with a technique developed by West-
inghouse Research Laboratories. A gallium-arsenide laser, radiating coherent infrared light, triggers a LASS (Light-Activated Silicon Switch). The photo shows one of the new switches. At the left is the light-guiding tube; in the center, the encapsulated switch; on the right is the working silicon wafer.

While the LASS is similar to a thyristor or SCR, it has certain advantages. The switching circuit is completely isolated from the load on the LASS, since light activation is used. Also, a series of LASS's in a stack may all be switched simultaneously by piping the laser beam to each.

A laser beam has also been used to record a holographic picture—a true three-dimensional image—without a lens. The photo shows Dr. Ronald Lundgren of Hughes Aircraft Co. making a recording of small figurines.

At 300 rpm all you can hear is the music.

Most turntables utilize motors that operate at 1800 rpm. The new Sony Servo-Controlled TTS-3000 employs a motor that provides optimum torque at 300 rpm. The first precision servo-controlled tube, no noise, precise speed, beautiful music use extra.

A Sony VC-8E moving coil cartridge, $65 85. Prices, suggested list. At your Sony high America, Dept. H, 47-47 Van Dam Street.
THE RIGHT HAND KNOWETH NOT...

Dear Editor:

In the November 1966 issue, I found a very amusing cartoon on page 51. This witty cartoon shows a TV camera and receiver, which seem to replace most advantageously the mirror of our ancestors. Yet there is in the cartoon an error which would make the use of the system difficult at least.

On the TV screen, the man is seen as in a mirror. He is shaving his right cheek, while his image shaves the left! That's wrong. A television system does not cause the right-left inversion produced by a mirror (except by inverting the horizontal sweep).

Paris, France

E. AISBERG

MORE ON FOREIGN AID

Dear Editor:

On page 15 of your November 1966 issue I noticed a letter from J. P. Saxena of Kathmandu, Nepal, who complained of American manufacturers not replying to letters, sending catalogs, etc. I can think of many reasons for his not getting replies from American manufacturers. They may not be familiar with the foreign postal regulations, or they may not have export facilities or proper arrangements to ship to foreign countries. Patent or other regulations limit the areas where they can sell their products.

If you will check with the US Dept. of Commerce office nearest you, you may find that Nepalese import regulations and high tariffs may make it nearly impossible for a person there to purchase parts from the US. Also, our prices, when paid for in their limited-value currency, might make parts that are simple and cheap to us prohibitively expensive there. Perhaps manufacturers just don't know how to handle his requests.

MERRITT L. PERKINS

Three Rivers, Mich.

Dear Editor:

In reading "Correspondence" in the November 1966 issue, I have this to add about "Foreign Aid." Out of 20 manufacturers I have written concerning their products, only about 3 or 4 answer the first inquiry. The others wait for from 3 to 5 letters, if they answer at all. One in particular I wanted an answer from and sent a certified letter over a year ago. Never did receive an answer.

If this office snobbery is current to people in the States, I can understand the foreign trouble. I am sure (the manufacturers') views are "%! with the one-item purchaser."

Leo E. Smith

Sandy, Utah

TAPES BY MAIL

Dear Editor:

The letter in Jack Darr's "Service Clinic" column of November 1966 regarding erasing of tapes sent overseas was of special interest to me. His reply was correct, but there was one factor left out. All outgoing packages passing through customs offices either here or overseas are passed under an X-ray machine. You know what would happen to a sound tape going under such radiation—complete erasure. Postal authorities stress that any shipments of sound or data recordings made magnetically on tape be clearly marked:

SOUND TAPE RECORDING

DO NOT X-RAY

This is true as well of the tapes coming back into the US from abroad.

L. Norman Gray

Indianapolis, Ind.

ENGINEERS AND TECHNICIANS

Dear Editor:

As a retired EE, I have filled in a few spare moments checking the TV sets and radios of my close relatives. Most have had repairs by TV servicemen, resulting in varying degrees of performance. None were entirely satisfactory, which was the reason I was prevailed
WHEN YOU BUY THIS RCA WR-64B COLOR BAR/DOT/CROSSHATCH GENERATOR...THE ESSENTIAL COLOR TV TEST INSTRUMENT

Here's a deal you can't afford to miss! A FREE Remington portable typewriter—yours when you purchase the most essential color TV test instrument—the RCA WR-64B!

Just imagine how handy your new typewriter will be—in the shop or at home. You'll use it almost as much as you use the RCA WR-64B—standard of the color TV servicing industry.

Here's how to get your FREE Remington Typewriter. Mail in the warranty card plus the gold label from the shipping carton of your new RCA color bar generator to RCA Test Equipment Headquarters, Bldg. 17-2, Harrison, N.J. We will ship your new Remington portable typewriter to you direct, freight prepaid. But remember—this offer covers only equipment purchased between February 1, 1967 and May 15th, 1967. To allow for postal delay, we will honor cards postmarked up to May 31st.

Plan NOW to take advantage of this BIG offer—a FREE Remington portable typewriter with your purchase of an RCA WR-64B color bar/dot/crosshatch generator.

The standard of the Color-TV Servicing Industry, Generates all necessary test patterns—color bars, crosshatch, dots plus sound-carrier.

Only $189.50*

*Optional Distributor resale price. All prices subject to change without notice. Price may be slightly higher in Alaska, Hawaii, and the West.

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RCA Electronic Components and Devices, Harrison, N.J.

The Most Trusted Name in Electronics
When a Pioneer Speaks...it's time to listen!

That's when you'll hear the optimum in tonal quality...sound reproduction at its faithful best. You can always count on Pioneer speakers and speaker systems to deliver a quality performance. Every time. All the time.

Made by the world's largest manufacturer of speakers, this premium audio equipment available at popular prices. And you can select from many fine models—from the unique, handsome metal-grilled CS-24 Auxiliary Wall Speaker to the efficient, compact CS-20, CS-52 and the Ultimate 5-speaker CS-61 Bookshelf System. All carried only by franchised dealers.

A word from you and we'll send literature and the name of your nearest dealer.

(a) CS-52 Bookshelf 3-way speaker system (3 speakers). Oiled walnut enclosure. Mass. 2544 x 15¾ x 11¾", retail price: $142.00.

(b) CS-61 Bookshelf 3-way speaker system (5 speakers). Oiled walnut enclosure. Mass. 24¾ x 16½ x 13¾", retail price: $175.00.

CORRESPONDENCE continued

upon to examine them.

My examination showed a lack of knowledge in the art of soldering. Great gobs of solder on joints, with splashes of solder on other components, left there with no regard for possible future troubles. Substitute parts, including tubes, were not always equivalent or direct replacement types. It seems that many parts were "hung on" in the hope that the picture would be restored to normal with no regard for exactness.

I would also add my voice to the many who have made objections to the lack of foresight on the part of manufacturers regarding "serviceability." Repair costs are aggravated by inaccessibility. In addition, proper ventilation is seldom considered in the design of TV chassis—at least, not to any great extent that I have seen.

Let's plead for practice on the part of repairmen so that repairs which depend upon solder connections will be well done.

B. P. SCHROEDER

La Puente, Calif.

TO HELP RELIEVE TECHNICAL SHORTAGE

Dear Editor:

The University of Illinois will introduce an entirely new course of instruction and training in microprecision technology on February 1. This course will be offered tuition-free to 60 young people across the nation who can qualify.

The demand for people with microprecision knowledge and skills is great and placement opportunities of the program are unusual; many challenging offers for rewarding careers will be open to graduates.

The course will furnish experience in electronics, instrumentation, machine work, precision production of electronic circuits and mechanical elements, mechanical systems, and applied economics, among others.

To apply for this unusual tuition-free training, students must be graduates of an approved high school or have equivalent credentials, be 18 to 25 years of age, in good health, and have completed high school work in algebra.

HUGH G. WALES

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A two-transistor—high and low band—amplifier in one compact weather-resistant housing. Engineered to provide the lowest noise and highest amplification with the most desirable overload characteristics. Designed for easy and convenient installation on antenna boom, mast, or under roof eave.

Amplifier used in conjunction with dual outlet power supply for one, two, or multiple set installations (with Finco 3003 coupler). 117 V 60 cycle input. AC power up to amplifier: 24 volts - 60 cycle. Metal enclosed with easy keyhole mounting. Amplifier and power supply provided complete with mounting hardware. Each unit tested and inspected prior to shipment.

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BEGIN WITH "AUTOTEXT" INSTRUCTION METHOD!

Start to learn the field of your choice immediately!
No previous training or experience in electronics needed!

With this new revolutionized method of home training you pick the career of your choice—and RCA Institutes trains you for it. RCA’s Career Programs assure you that everything you learn will help you go directly to the field that you have chosen! No wasted time learning things you’ll never use on the job! The Career Program you choose is especially designed to get you into that career in the fastest, easiest possible way!

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CHOOSE A CAREER PROGRAM NOW
Your next stop may be the job of your choice. Each one of these RCA Institutes Career Programs is a complete unit. It contains the know-how you need to step into a profitable career. Here are the names of the programs and the kinds of jobs they train you for. Which one is for you?

Television Servicing. Prepares you for a career as a TV Technician/Serviceman; Master Antenna Systems Technician; TV Laboratory Technician; Educational TV Technician.

FCC License Preparation. For those who want to become TV Station Engineers, Communications Laboratory Technicians, or Field Engineers.

Automation Electronics. Gets you ready to be an Automation Electronics Technician; Manufacturer’s Representative; Industrial Electronics Technician.

Automatic Controls. Prepares you to be an Automatic Controls Electronics Technician; Industrial Laboratory Technician; Maintenance Technician; Field Engineer.

Digital Techniques. For a career as a Digital Techniques Electronics Technician; Industrial Electronics Technician; Industrial Laboratory Technician.

Telecommunications. For a job as TV Station Engineer, Mobile Communications Technician, Marine Radio Technician.

Industrial Electronics. For jobs as Industrial Electronics Technicians; Field Engineers; Maintenance Technicians; Industrial Laboratory Technicians.

Nuclear Instrumentation. For those who want careers as Nuclear Instrumentation Electronics Technicians; Industrial Laboratory Technicians; Industrial Electronics Technicians.


SEPARATE COURSES
In addition, in order to meet specific needs, RCA Institutes offers a wide variety of separate courses which may be taken independently of the Career Programs, on all subjects from Electronics Fundamentals to Computer Programming. Complete information will be sent with your other materials.

LIBERAL TUITION PLAN
RCA offers you a unique Liberal Tuition Plan—a most economical way to learn. You pay for lessons only as you order them. No long term contracts. If you wish to stop your training for any reason, you may do so and not owe one cent until you resume the course.

VALUABLE EQUIPMENT
You receive valuable equipment to keep and use on the job—and you never have to take apart one piece to build another. New—Programmed Electronics Breadboard. You now will receive a scientifically programmed electronic breadboard with your study materials. This breadboard provides unlimited experimentation with basic electrical and electronic circuits involving vacuum tubes and transistors and includes the construction of a working signal generator and superheterodyne AM Receiver.

Bonus From RCA—Multimeter and Oscilloscope Kits. At no additional cost, you will receive with every RCA Institutes Career Program the instruments and kit material you need to build a multimeter and oscilloscope. The inclusion of both these kits is an RCA extra.

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FREE PLACEMENT SERVICE
In recent years, 9 out of 10 Resident School students who used the Free Placement Service had their jobs waiting for them when they graduated. And many of these jobs were with top companies in the field—such as IBM, Bell Telephone Labs, General Electric, RCA, and radio and TV stations and other communications systems throughout the world.

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The Most Trusted Name in Electronics
SERVICE CLINIC

In the Shop . . . With Jack

By JACK DARR

What Can You Do With A Microammeter?

DARN NEAR ANYTHING. EXAMPLE: YOU can't get along in two-way radio serving without one, for many transceivers have built-in metering circuits for alignment, transmitter tuneup and loading, etc., using a 0-50 microampere meter. In FM sets, or in any stage which is normally driven into the grid-current region, the grid current of an i.f. amplifier, etc., is directly proportional to the input signal strength (up to the limiting point, of course).

Here's another one: Once in a while, we'd like to read the actual grid voltage of a vhf or hf oscillator. But, if we put a meter across the circuit, even a vvm may either throw it out of oscillation, or detune it so badly that our reading is meaningless. Beside this, some ac voltmeters aren't too accurate up around 50-150 MHz!

So, how can we read the amplitude of oscillation? Open the bottom end of the grid resistor and insert the microammeter. Now, we can turn the oscillator on, and note the reading in microamps; multiply this by the value of the grid resistor, and we have the peak value of the grid-voltage signal. Since the grid draws current only on positive peaks, this represents peak, not p-p voltage. The absolute accuracy of the reading is determined by the tolerance of the grid resistor. Anyhow, it's a very useful check, when we need to know whether an oscillator is working or not, and delivering a certain amount of signal into the following circuits.

This same test can be used on vhf frequency-multiplier circuits, or in any stage working class B, which means that it is drawing grid current at least part of the time. Class C stages of course will give lower, but still useful readings. In frequency multipliers, meter the grid current of the multiplier stage, while tuning up the plate or output circuit of the oscillator. If it's a multiple-stage multiplier, read the grid current of one stage while tuning the preceding circuit for maximum output on the desired frequency.

Another use—read rf output of very small CB transmitters. Just hook a diode (any kind) either in series or shunt with the microammeter, and add a pickup rod to get some signal. The diode rectifies the rf output of the transmitter, and the resulting dc is read on the meter. You can ground the other side of the meter, although this usually isn't necessary (see Fig. 2). Tune the transmitter for a peak reading on the meter. For best results, keep the pickup rod at least ¼ wavelength away from the antenna (about 9 feet at 27 MHz).
15K in series (so that you come out with 5,000 + 15,000 = 20,000 = 1.0 volt.) If yours happens to have 0-1.2 volt on the lowest range as one popular make does, simply add enough to make it read where you want it to. Make your multiplier up so that the total resistance will be the desired full-scale reading in volts, multiplied by the ohms-per-volt rating. For example, if your lowest scale was 12.0 volts, and you wanted 0-1.2 V., the total resistance would be 1.2 x 20,000 or 24K; subtract 5K for the meter and your multiplier comes out to a value of 19K.

You can install the multiplier resistor inside a standard test prod, and label it. Then, all you have to do is plug it in, set the selector switch to micro-ampere, and you're ready to go.

To do this, you need to be sure of the correct meter resistance of your voltmeter or microamps scale. (Some have more than one!) Ordinarily, this will be 5K, but, unless this is so stated in the instruction manual, you can't be certain. Check it.

Get a 1.5-volt battery and an old 1-meg volume control, and a 10K pot. Hook the meter, volume control and battery in series, as in Fig 3-c, and be sure that the volume control is set to maximum resistance. In fact, it's a very convenient way to do this.

---

**Clever Kleps 30**

Push the plunger. A spring-steel forked tongue spreads out. Like this Hang it onto a wire or terminal, let go the plunger, and Kleps 30 holds tight. Bend it, pull it, let it carry dc, sine waves, pulses to 5,000 volts peak. Not a chance of a short. The other end takes a banana plug or a bare wire test lead. Slip on a bit of shield braid to make a shielded probe. What more could you want in a test probe?

Available through your local distributor, or write:

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Circle 20 on reader's service card
How To Have Fun While You Save...

Regardless
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It Can't Perform As
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New Heathkit "180"
For Only $379.95*

Here's Why!

Exclusive Features
That Can't Be Bought In Ready-Made Sets At Any Price!

All color TV sets require periodic convergence and color purity adjustments. This new Heathkit GR-180 has exclusive built-in servicing aids so you can perform these adjustments anytime...without any special skills or knowledge. Just flip a switch on the built-in dot generator and a dot pattern appears on the screen. Simple-to-follow instructions and detailed color photos in the GR-180 manual show you exactly what to look for, what to do and how to do it.

Results? Beautifully clean and sharp color pictures day in and day out...and up to $200 savings in service calls throughout the life of your set.

Exclusive Heath Magna-Shield!

This unique metal shield surrounds the entire picture tube to help keep out stray external fields and improve color purity. In addition, Automatic Degaussing demagnetizes and "cleans" the picture everytime you turn the set on from a "cold" start...also permits you to move the set about freely.

Vertical Swing-Out Chassis!

All parts mount on a single, one-piece chassis that's hinged to make it more accessible for easier construction, care and installation.

Your Choice Of Installation!

Another Heathkit exclusive...the GR-180 is designed for mounting in a wall or your own custom cabinet. Or you can install it in either of Heath's factory-assembled and finished cabinets.

From Parts To Programs In Just 25 Hours!

...and no special skills or knowledge needed. All critical circuits (VHF and UHF tuners, 3-stage IF assembly and high voltage power supply) are prebuilt, aligned and tested at the factory. The GR-180 manual guides you the rest of the way with simple, non-technical instructions and giant pictorials. It's like having a master teacher at your elbow pointing out every stop. You can't miss.

Compare These Advanced Performance Features...And The Price!

Hi-Fi 180 Sq. Inch Rectangular Tube with anti-glare safety glass, plus "true earth phosphors", smaller dot size and 24,000 volt picture power for brighter, livelier colors and sharper picture definition.

Automatic Color Control and gated automatic gain control to reduce color fading, and insure steady, jitter-free pictures even under adverse interference such as nearby aircraft traffic.

Deluxe VHF Tuner with "memory" fine tuning so you don't have to readjust everytime you return to a channel.

2-Speed Transistor UHF Tuner for either fast station selection, or fine tuning of individual channels.

Two Hi-Fi Sound Outputs...a cathode follower for play through your hi-fi system; plus an 8 ohm output for connection to the GR-180's limited-field 4" x 6" speaker.

Two VHF Antenna Inputs...a 500 ohm balanced and a 75 ohm coax to reduce interference in metropolitan or CATV areas.

1-Year Warranty on the picture tube, 90 days on all other parts. In addition, liberal credit terms are available.

*Kit GR-180, everything except cabinet for custom mounting, $379.95
Assembled GRA-180-1, walnut cabinet shown above, 30 lbs., $439.95
Assembled GRA-180-Z, Early American cabinet, $39.95

New 12" Transistor Portable TV —
First Kit With Integrated Circuit

Unusually sensitive performance. Plays anywhere...runs on household 117 v. AC, any 12 v. battery, or optional rechargeable battery pack ($39.95).

Receives all channels; new integrated sound circuit replaces 39 TV parts; 3-stage IF for maximum gain with controlled bandwidth; gated AGC for steady, jitter-free pictures; instant "on" AGC operation; preassembled & aligned tuners for peak performance; transformer operated power supply; front panel mounted speaker; easy 12-hour assembly. Rugged high impact plastic cabinet measures a compact 11½" H x 15½" W x 9½" D. 27 lbs.

Kit GR-104
$119.95

Circle 21 on reader's service card
Build Your Own Heathkit® Electronics

Heathkit “Starmaker”
60-Watt Transistor Guitar Amp

Kit TA-16
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$300 Value!

NEW Transistor Portable Phonograph Kit

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60 watts peak power; two channels — one for accompaniment, organ or mike, the other with tremolo and reverb for lead guitars; two inputs per channel; two 12" heavy-duty speakers; line bypass reversing switch for hum reduction; 13 transistor, 6 diode circuit; 28" W x 9" D x 19" H. Leather-textured black vinyl cabinet of ¾" stock; 120 v. or 240 v. AC operation; extruded aluminum front panel. 52 lbs.

Worth At Least 50% More! And it sounds better. Assembles in just 1 to 2 hours . . . simply wire one small circuit board, mount the 4" x 6" speaker and plug in the preassembled changer . . . ideal beginner’s kit. Features automatic mono play of all 4 speeds; dual Sapphire stylus for LP’s or 78’s; 45 rpm adapter; olive and beige polyethylene over sturdy, preassembled cabinet. Operates on 117 v. AC. 23 lbs.

Enjoy World-Wide Listening
With This Low-Cost Shortwave Receiver!

Kit GR-84
$84.95

Kit GR-64
$37.95

Compare It To Sets Costing $150 And More! 5 bands cover 200-400 kHz, AM and 2-30 MHz. Tuned RF stage, crystal filter for greater selectivity, separate detectors for AM and SSB, tuning meter, bandspread tuning, code practice provision, automatic noise limiter, automatic volume control, antenna trimmer, built-in 4" x 6" speaker, headphone jack, gray metal cabinet and FREE SWL antenna. 25 lbs.

Hear Live Broadcasts From Hundreds Of Foreign Countries, Voice of America, Radio Moscow, hams, ship-to-shore radio, weather and popular AM. Covers 550 kHz to 30 MHz — includes AM plus 3 shortwave bands; 5" speaker; bandspread tuning; signal strength indicator; 7" slide-rule dial; BFO; 4-tube circuit plus 2 rectifiers; noise limiter; external antenna connectors; gray aluminum cabinet, AM antenna. 15 lbs.

NEW Heathkit®/Magnecord® 1020 4-Track Stereo Recorder Kit

Kit AD-16
$399.95

(less cabinet)

Save $170 By Doing The Easy Assembly Yourself.

Takes around 25 hours. Features solid-state circuitry; 4-track stereo or mono playback and record at 7¾ & 3¾ ips; sound-on-sound, sound-with-sound and echo capabilities; 3 separate motors; solenoid operation; die-cast top-plate, flywheel and capstan shaft housing; all push-button controls; automatic shut-off at end of reel; plus a host of other professional features. 45 lbs. Optional walnut base $19.95, adapter ring for custom or cabinet installation $4.75

FREE!
World’s Largest Electronic Kit Catalog!

Describes these and over 200 kits for stereo hi-fi, color TV, amateur radio, shortwave, test, CB, marine, educational, home and hobby. Save up to 50% by doing the easy assembly yourself. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

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☐ Enclosed is $_____, plus shipping.

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Prices & specifications subject to change without notice.

CL-279

FEBRUARY 1967
**SERVICE CLINIC continued**

A good idea to set the VOM to the 100-

 **mA** scale, and then turn it down to

the microamps scale, just to be sure that

the thing isn't going to slam the meter.

Now, adjust the 1-meg control un-

til the meter reads exactly full-scale on

the microamps range. Now, connect the

10K pot across the meter terminals and

adjust it so the meter deflection is re-

duced by exactly half. Disconnect the

battery and meter, and, without moving

the slider, read the resistance of the 10K

pot. This is equal to the meter resis-

tance. When the meter reading drops to

half scale, the pot shunted across it will

be carrying exactly half of the current

and its resistance is equal to that of the

meter.

Be sure to hook the test pot across

the VOM test leads; never across the

meter movement inside the instrument. Why?

Because many meters use series-resis-

tance in order to bring the meter-resis-

tance up to 5K so that the 20,000-ohms-

per-volt calibration will be easier. The

actual meter resistance depends on

the number of turns in the moving coil, the

size of wire, the magnetic flux and so on.

The basic movement may not be 0–50

µA; Hickok, for example, uses a meter

movement with a "bare" sensitivity of

38 µA, and this is multiplied up to give

0–50 µA full-scale.

So, with a little imagination, and a

great deal of caution, and a few odd re-

sistors, you can make your VOM much

more useful around the shop.

**Signal-tracing vertical amplifier in scope**

I have an Elco 460 oscilloscope

that I built from a kit. It's worked fine

for several years, but now I have hardly

any vertical gain, even with the control

wide open. The vertical gain's good for

about 10 minutes after I turn the scope

on, then down the goes. I've changed

tubes and checked voltages, which seems to

be okay. What to do? — S. H., Attle-

boro, Mass.

Everybody ought to have two

scopes—one for working on the other

one. However, you can use the oldest

method of trouble-chasing there is:

signal substitution. Feed an audio signal

into your vertical deflection system,

stage by stage. This will tell you which

stage is losing gain.

The CRT takes about 50 volts to

deflect the trace 1 inch (without look-

ing up the exact figure), if you drive the

deflection plates direct. So, start here.

Use a signal from a test record through

an audio power amplifier, or try an audio

signal generator, if it has a high-

enough voltage output. Any test record

containing sine-wave audio will do.

Don't worry about the cartridge or the

amplifier's distortion — you're looking

for gain, not checking the scope's line-

arity. An audio generator will probably

have a Hi-Z output, which you can use.

If you use a hi-fi power amplifier,
pull a dummy load on the speaker ter-

minals. For instance, for a 20-watt ampli-

fier and an 8-ohm output, use a resist-

or (or resistors in total) that's about 8

ohms and 20 watts or more.

Use two blocking capacitors (0.1

or .05 µF at 600 volts) between your

audio source and the scope. If you don't

get enough voltage from the ampli-

fier's speaker output, hang one blocking

capacitor off the output plate, with the

other to chassis. Feed this audio direc-

tely into the vertical output tubes. (They're

push-pull, which is why you need two capacitors.) Now, note the vertical deflection of the CRT trace. It

should be about 1 inch for 50 volts ac,

which you should measure with your

voltmeter. If deflection is satisfactory

at the plates, go back and insert signal at

the output grids. In this way, follow the

vertical amplifier circuit all the way

to the input.

Somewhere along the line, you won't get the gain you should—most of these stages are pretty high-gain voltage

amplifiers, and you ought to get at least

a 20–25 times voltage gain through

each. As you move backward from the

output, you'll have to keep turnover down

to the gain on your audio source.

When you hit the spot where you don't have to, that'll be the faulty stage. Trouble's probably an open or leaky

coupling capacitor, to judge from your

description.

**Bending in Heath GR-25**

I've got a problem in a Heathkit

GR-25 color TV. The picture pulls or

bends whenever video information

leaves or comes on the right side of the

screen. Vertical lines will bend toward

dark areas; this is actually the raster

pulling, and it's been there ever since

the set was assembled.

I've replaced all tubes in the

horizontal section, sync and agc, and

checked everything I can think of.

There is no ripple on the B+ filter capa-

citors, as seen with a scope. Any sugges-

tions? — J. M., Glendale, N. Y.

This sounds very much as if you have some kind of trouble in the

blacker. I would make a very careful

check of that stage, being sure that all

parts have the right value, all ground

connections are solid, and so on.
Interchangeable scope tubes?

I have an EICO 425 scope with a 5BP1 tube. A while ago, I bought a surplus 5BP4 tube. I put this into the scope, and got no focus or intensity adjustment, and the pattern is about 3/16-inch wide! What changes do I have to make to use this tube? Other tubes in the scope are okay.—H. K., Long Beach, Calif.

I'm afraid the only change you need to make is to throw that surplus tube away and get a good one! The 5BP1 and 5BP4 tubes are fully interchangeable. The only difference is in the phosphor. The P1 phosphor is the standard scope phosphor, green with medium persistence; the P4 phosphor is the same as that used in TV picture tubes—white, with about the same persistence.

The basing and all electrical characteristics of these two tubes are the same. So, the 5BP4 should have worked, but made a white pattern.

The only hope I can see in this case would be to check the base pins of the 5BP1; you just might have a bad solder joint there, which is opening one of the elements—from the symptoms, maybe the screen grid.
Gene Frost was "stuck" in low-pay TV repair work. Then two co-workers suggested he take a CIE home study course in electronics. Today he's living in a new house, owns two good cars and a color TV set, and holds an important technical job at North American Aviation. If you'd like to get ahead the way he did, read his inspiring story here.

If you like electronics—and are trapped in a dull, low-paying job—the story of Eugene Frost's success can open your eyes to a good way to get ahead.

Back in 1957, Gene Frost was stalled in a low-pay TV repair job. Before that, he'd driven a cab, repaired washers, rebuilt electric motors, and been a furnace salesman. He'd turned to TV service work in hopes of a better future—but soon found he was stymied there too.

"I'd had lots of TV training," Frost recalls today, "including numerous factory schools and a semester of advanced TV at a college in Dayton. But even so, I was stuck at $1.50 an hour."

Gene Frost's wife recalls those days all too well. "We were living in a rented double," she says, "at $25 a month. And there were no modern conveniences."

"We were driving a six-year-old car," adds Mr. Frost, "but we had no choice. No matter what I did, there seemed to be no way to get ahead."

Leans of CIE

Then one day at the shop, Frost got to talking with two fellow workers who were taking CIE courses...preparing for better jobs by studying electronics at home in their spare time. "They were so well satisfied," Mr. Frost relates, "that I decided to try the course myself."

He was not disappointed. "The lessons," he declares, "were wonderful—well presented and easy to understand. And I liked the relationship with my instructor. He made notes on the work I sent in, giving me a clear explanation of the areas where I had problems. It was even better than taking a course in person because I had plenty of time to read over his comments."

Studies at Night

"While taking the course from CIE," Mr. Frost continues, "I kept right on with my regular job and studied at night. After graduating, I went on with my TV repair work while looking for an opening where I could put my new training to use."

His opportunity wasn't long in coming. With his CIE training, he qualified for his 2nd Class FCC License, and soon afterward passed the entrance examination at North American Aviation. "You can imagine how I felt," says Mr. Frost. "My new job paid $228 a month more!"

"CIE training helped pay for my new house,"

says Eugene Frost of Columbus, Ohio
Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living
Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important
Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

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Accredited Member National Home Study Council
Solid-State C-D Ignition Under $25

Here's a capacitor-discharge system that's simple and easy to build, that will put you with the "go" crowd

By BRICE WARD

IF YOU'VE BEEN HANKERING FOR A compact and powerful solid-state system to add a little zest to the family chariot, try this one for size. No bigger than a couple of packs of cigarettes, it packs a 40-kV punch. It won't crown you king of the drag strip, of course, but if your bug can benefit from an improved ignition system, you can soon be on your way—for darned little effort or cash outlay.

This project started when the price of most capacitor-discharge ignition systems seemed high for experimenting. I wondered if it were possible to build one for about half the cost of current systems, and if so . . . what kind of performance would it have?

It was obvious that price and performance depended primarily on the availability of a high-quality, low-cost inverter transformer. Also, using a common-emitter circuit could mean fewer resistors, lower cost and better efficiency. A search through many parts catalogs suggested the Triad TY68-S, priced at $7.52.

The rated full load supply voltage quoted by Triad for the TY68-S may seem low, but operating as this system does, the actual voltage stored on C1 is about 375 volts measured with a vtvm at 14.7 volts input. This allows more than adequate voltage to be supplied to the sparkplugs on starting and idling and even though the voltage may drop slightly as RPM increases it will never become inadequate below 6,000 RPM.

Inverter efficiency is high. As shown in Fig. 1, the 26.5-volt collector swing has less than 10% overshoot. The 2-volt drive requirement is low, and idling current for the unloaded inverter is about 0.6 amp—lower than any commercial system I've seen. The output waveform, using a Mallory U12 coil and with 12 volts at the inverter, is shown in Fig. 2.

The principles used in this project are given in Motorola's Power Transistor Handbook on page 115. They show a simple transformer inverter in a common-emitter circuit.

Fig. 3 is the schematic of the ignition system. The inverter runs at 2 kHz and uses a bridge rectifier to charge capacitor C1 during the points-closed portion of the ignition cycle.

The triggering circuit was designed to accomplish four things: First, it has a relatively high input impedance (compared to other triggering circuits),

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Fig. 1—Waveform found at the Q2 collector is shown with normal 12 volts dc at the input lead of the inverter.

Fig. 2—Ignition-coil output using C-D system. Peak at left measures 40 kV above the zero center line on scope.

Location of major components which are mounted within the equipment cabinet.
allowing it to function with dirty points. Second, it will deliver a pulse with a 10-volt swing to a tachometer attached to the distributor connection. Third, high-voltage transients such as an arc from the ignition-coil tower to the distributor or 12-volt connection on the coil will not damage transistor Q3. Fourth, the circuit can easily be adapted to photoelectric or magnetic triggering.

During points-closed operation, capacitor C3 is charged to the supply voltage minus the drop across diode D5 (Fig. 4). The charging time constant is short enough to allow, theoretically at least, operation to 10,000 rpm in an 8-cylinder engine.

The drop across D5 is maintained by current flow through R4 and serves to bias the SCR gate to -0.6 volt with respect to the cathode. Q3 is turned on as the points open, discharging C1 through the primary of the ignition coil to supply the stepped-up high-voltage pulse to the plugs via the distributor.

Commutation is a term you will see frequently in connection with SCR’s and it refers to the means used to turn the SCR off after the desired period of conduction. Some systems “crowbar” (short) the output of a self-biased common-collector inverter. This shuts the inverter off, allowing the flywheel action of the coil to finish the turnoff of the SCR.

Since this circuit does not use a self-biased inverter, the reverse swing of the coil is used to commutate the SCR, a system which has proved very satisfactory.

C2 (Fig. 3) is used to prevent too swift an application of voltage to the anode of the SCR, which would result in a phenomenon known as the dV/dT effect. A too-rapid application of voltage to the anode can cause the SCR to turn off without a gate pulse. This uncontrolled firing would raise (and has raised) hob with an engine. The value of R3 is not really critical (though it should be greater than 1 megohm), since its main purpose is to discharge C1 when power is removed from the circuit.

The secret of both the size and cost of this unit is embodied in the Triad TY68-S inverter transformer. This transformer originally was designed for photoflash circuits. Although relatively low in cost, it’s very efficient.

Since the entire circuit is assembled on a circuit board, you’ll want to have a negative made of the full-size artwork shown in Fig. 6. You can have a copper-backed board made by a commercial shop or do the job yourself using materials and instructions supplied by any of several manufacturers listed in parts catalogs.

Drill all holes except the two transformer mounting holes with a No. 55

Fig. 3—Schematic of the C-D SCR ignition system. Heart of circuit is de-to-dec inverter transformer, which must produce efficient drive to SCR triggering device.

Fig. 4—When the distributor points open, system fires, and current flows as indicated by arrows on the diagram.

Fig. 5—Mount components on the board using this diagram as a guide. Be sure to drill all holes and cut board to size before putting parts in place. Solder carefully and work rapidly, as too much heat can destroy foil or components. Use a heat sink.

F E B R U A R Y  1 9 6 7

![Schematic diagram of SCR ignition system](image)

**PARTS LIST**

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
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<tbody>
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</tr>
<tr>
<td>D5</td>
<td>Motorola 2N4613 or equivalent</td>
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<tr>
<td>Q1</td>
<td>Texas Instruments 2N697 or equivalent</td>
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<td>R1</td>
<td>150 ohms, 1/2 watt</td>
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<td>R2</td>
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<tr>
<td>Q3</td>
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<tr>
<td>Q4</td>
<td>Texas Instruments 2N697 or equivalent</td>
<td></td>
</tr>
<tr>
<td>Transformer</td>
<td>12.6 volts to 250 volts (Triad TY68-S or equivalent; Newark 3F-438)</td>
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<td>Cabinet</td>
<td>LMB type 876 Jiffy Box, 4 x 2 x 2¾ inches, or equivalent</td>
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<tr>
<td>Transistor mounting kits</td>
<td>Motorola type MK-15</td>
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high-speed steel drill. Drill the two transformer mounting holes with a No. 33 drill. Shear the circuit board to size, and you're ready to install the components (Fig. 5).

Drill holes in the chassis and install the transistor sockets and transistors. Install the SCR with the anode solder lug inside the case. The SCR should be insulated from the chassis using the mica washers or other insulating material supplied with the device.

The transformer requires some special treatment. First, cut all leads except the two high-voltage leads so they extend just to the edge of the transformer frame—about 1/4 inch. Carefully untwist all the double primary leads. With a knife or sandpaper remove the enamel insulation, then twist the leads and carefully tin them. Also strip and tin the two single leads.

In the prototype, a 10-inch length of four-conductor vinyl-jacketed intercom cable connects the transformer to the transistor sockets. If you use a similar procedure, try to obtain a cable having red, black, green and white leads. Remove 2 inches of vinyl jacket from each end of the cable and strip 1/2 inch of insulation from each lead. Connect the red lead to C2, the black lead to C1, the green lead to B1, and the white lead to B2, the transformer primary taps.

Connect the other end of the green lead to Q1 base, the black lead to Q1 collector, the white lead to Q2 base, and the red lead to Q2 collector. A short jumper of insulated wire connects the two emitters, and a 10-inch single-conductor lead is attached to Q2 emitter as a return to the circuit board.

Take a 5-inch length of the same cable and strip the vinyl jacket, so you can remove the red, green and black leads. Strip 3/4 inch of insulation from each end of each piece of wire and connect as follows: black to the cathode of the SCR, and red to the anode lug located inside the case. A long section (3 or 4 feet) of the vinyl-jacketed cable connects the chassis unit to the automobile system.

Wire the remainder of the unit as indicated in Fig. 3. Lead length and dress aren't important. Install the transformer on the circuit board using 4-40 machine screws and nuts. Connect the two red high-voltage leads to the diode bridge as shown in Fig. 5.

Mount the ignition system on the fender ledge or fire wall and follow the instructions below, using the two split-diagonal terminal boards shown in Fig. 7. Here's how:

Step 1—disconnect all leads from the coil stud where the ignition-switch lead is attached. Remove all clips, stampings and washers from the coil stud itself.

Step 2—install terminal board with a red and a white wire to the coil stud from which the leads were removed. Replace only the lock washer and nut.

Step 3—connect the leads removed in Step 2 to the outer terminal on the board and install a lock washer and nut.

Step 4—disconnect all leads from the coil stud to which the distributor lead is connected. Remove any clips, stampings or washers.

Step 5—install the terminal board with a green and a black wire to the coil stud from which the leads were just removed. Replace only the lock washer and nut.

Step 6—connect the leads removed above to the outer terminal on the board. Install and tighten the lock washer and nut.

Collector-emitter shorts will cause the inverter to quit. This is the most common problem you'll experience. Of course, if you should get the feedback leads reversed, the system will quit, too—so pay particular attention to this point.

Beyond these potential troubles, circuit-board construction allows little room for wiring errors, and you should enjoy the product of your efforts for a long time.
Cartridge Systems and Quality

Four highly individual cartridge-construction concepts are related to actual sound quality—producing some surprising results  

By LEONARD SILKE

Perhaps the least considered component in a music system is the phono cartridge. Yet, this is where the reproduced sound begins. To the cartridge falls the extraordinarily delicate job of translating the highly complex undulations of a record groove into a minute electrical current which the amplifier will expand to levels capable of driving your speaker. This is no mean trick, considering the comprehensive range of information contained in a modern stereo groove. With two channels of information, one cut into each of two opposite walls, the stylus is required to move freely to any point within a 180° arc across the groove.

Translation of this mechanical motion into an electrical signal is not without losses; no cartridge is a perfect transducer. And, no two cartridges sound quite the same, even among those of "identical" manufacture.

In this report, we will examine four new cartridges, each of which has been selected as representative of a type using a different transduction system.

Basic electrical theory tells us that moving a magnet near a coil will generate an output voltage. Two of the four cartridges are of this magnetic variety. It is possible to generate a voltage using either a stationary magnet and a moving coil, a stationary coil and moving magnet, or a stationary magnet and coil.

How do you obtain a signal when both components are static? Any magnet has an area surrounding it that is affected by its flux field. If a piece of iron is placed within the field, it will assume some properties of a magnet. Any motion of the induced magnet in the presence of a coil will generate a signal of some value.

The ADC-10E cartridge represents an application of this principle. Magnetism is induced into a tiny iron collar by a fixed permanent magnet. This collar is at the end of the stylus lever opposite the point and is moved between two poles directly in relation to the groove motion.

The Stanton 581EL is the latest cartridge to use the popular moving-magnet principle. The magnet itself is at the reverse end of the stylus lever, and is moved directly relative to the record groove.

In some cartridges the moving stylus bar is coupled directly to a pair of miniature coils. These rotate in the vicinity of a fixed magnet.

Magnetism is not the only way to excite a transducer. Nonmagnetic cartridges have been around for a long time. The popular and inexpensive piezoelectric or crystal cartridge is probably used in more record players than any other type.

Only recently, however, have nonmagnetic cartridges assumed an aura of respectability similar to that of magnetic types. The problem has been one of mass and stiffness. Piezo cartridges operate by stressing a crystalline substance that generates electricity when flexed. Until recently, the force required to flex the elements was considerable. Cartridges were stiff and large. A long and heavy stylus lever was needed to provide sufficient twist to produce a reasonable signal.

Output from these types is high. Further, the piezo cartridge is essentially amplitude-sensitive; that is, its output voltage depends on how far the stylus moves back and forth in the groove. By contrast, a magnetic cartridge generates a voltage which is proportional to how fast the stylus moves. This means in practice that a piezo cartridge will self-equalize, while a magnetic type requires external equalization.

There is a second potential advantage to nonmagnetic cartridges: They will not accept induced hum from nearby motors or transformers, thus simplifying installation.

With these thoughts in mind, we decided first to test the Grado B (Fig. 1). This cartridge uses a pair of piezoelectric strain generators designed to provide a response similar to that of magnetic generators. The Grado B therefore requires equalization as does a magnetic cartridge. It further differs from the usual piezo cartridge in that its output voltage is as low as that of most magnets; it must therefore have a preamplifier.

A nonmagnetic cartridge can be made physically lighter than a magnetic unit, and the Grado B weighs 3.5 gm. This compares to a typical magnetic type at 6–10 gm. Reduced mass at the end of the stylus arm will improve tracking significantly, particularly if the record is warped. (And what record is perfectly flat?)

So far, all cartridges mentioned have one common trait: All are electrical generators—they transform the mechanical motion of the stylus assembly into an equivalent electrical signal.

For as long as there have been cartridges, there have been attempts to design nongenerating units. The alternative, of course, is to use the stylus mo-

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tion to modulate an externally generated voltage. The most recent of these types is the new Euphonics CK-15-LS. This cartridge requires an external transistorized power supply to provide the fixed dc voltage which is modulated by the flexing motion applied to the two semiconductors.

Stylus motion is imparted to two ultraminiature silicon elements (Fig. 2) called Pixies. As they are flexed by stylus movement in the groove, they change resistance. This resistance variation affects the dc output of the power supply. Again, nonmagnetic construction results in a very lightweight (2-gm) cartridge.

So, here we have them: The Euphonics is a voltage modulator; the Grado B is a solid-state (piezoelectric) generator; the ADC-10E is an induced-magnet generator; and the Stanton 581EL a moving-magnet generator. Four cartridges with four different principles of operation—yet all are assigned the same job.

Audiophiles have argued endlessly over the relative merits of these systems. Our object in testing these devices was to determine if one basic cartridge concept is capable of giving a characteristic and identifiable quality. We don't imply that the cartridges selected for these tests are necessarily superior to any others. They were chosen because they represent various attempts to recreate the original sound as recorded on stereo records.

All the cartridges, save one, have elliptical stylis. The exception is the Grado B which is supplied with a conical stylus but is also available with an elliptical stylus.

All cartridges were mounted on slides to fit the Empire 980 arm. The Euphonics is inoperable without its power supply which is used between the cartridge and the preamp (or measuring equipment). The supply has a slide switch which may be set for an output similar in characteristic to a magnetic cartridge (low) or one that supplies an RIAA-compensated 0.5-volt (high) output. All our tests were performed in the low position.

In the listening tests all the cartridges were subjected to identical conditions. Only one stereo amplifier, preamplifier and speaker pair were used for all listening tests and measurements. Each cartridge was used to play the same group of records.

The tests

1—Output: The test record is the CBS Labs STR-100. Output is from a standard-velocity 1,000-Hz signal recorded first on the left and then on the right. The test record is recorded in a test record.

Fig. 2—Another solid-state cartridge—a modulated-dc unit—uses silicon chips which vary resistance as stylus flexes.

Fig. 3—Measured frequency response (upper curves) and channel separation (lower curves) of four popular phono cartridges. Solid lines represent left channel, dashed lines, right channel. Cartridges are Euphonics CK-15-LS (upper left) Grado B (upper right) ADC-10E (lower left) and Stanton 581EL (lower right). Scope traces show cartridge action on 1,000-Hz test record.

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The high output of the Euphonics could overload some transistor (and tube) inputs. The output test is not necessarily a qualitative indication.

2—Minimum tracking force required: This has been determined from several factors. The final figure contains a safety factor. It is by no means the minimal force figure; it is the amount of force that will permit tracking—in a good, low-mass, high-compliance arm—on the vast majority of records. A few may require more; many will get by with less. However, a tracking force figure is one case where it is better to err on the high side. Double the force required is much preferred to an even slightly too-light force. Contrary to popular belief, underweighted arms severely damage records due to stylus rattle in the groove. The wear increase due to reasonable over-force is insignificant.

3—Dynamic compliance: This is a measurement of the compliance under use. It bears no relationship to the usual static-compliance figures quoted in advertising. The figures also seem to show up the pointlessness of the cartridge-compliance race. Apparently, the wide range of figures recorded has little bearing on performance of the cartridge. Again, a CBS Labs disc—the STR-111—was used.

4—Intermodulation distortion: This is measured from the same record as above. The +9-dB figures represent higher degrees of modulation than the lower figure. The +6-dB figure represents a reading typical of average recording levels. Lateral-response distortion is not always identical to vertical-response distortion. Both, of course, are important in stereo reproduction. If the figures appear surprising in light of figures usually quoted for amplifiers and the like, rest assured that they are state-of-the-art. Only a few years ago a 5% figure was considered outstanding.

5—Frequency response and channel separation: Note that general rises or dips in response extremes in the graphs can be corrected by tone controls. Note also that some of the bass rise, particularly in the right channel, is actually on the test record (CBS Labs, STR-100).

Channel separation in decibels is not nearly as important as linearity. The relative separation loss between 500 to 10,000 Hz is particularly important.
Circuit-Breaker Testing

Our service editor describes the "black box" that he built for a quick-check evaluation of all types of TV and radio circuit breakers.

By JACK DARR

THE BIG COLOR SET SAT ON THE BENCH, and I sat on my stool and glared at it. "Everything" had been checked—B+ current well within tolerance, tubes okay, no capacitor leakage. Turned the thing on, and in 90 seconds "pweeek!" went the circuit breaker.

I got mad. Picking up a test lead, I clipped it right across the breaker terminals, turned the set on, and spat, "All right, smoke, darn you!" It didn't—but 20 minutes later, the receiver was on its way home with a new circuit breaker, and I was on my way to the coffee shop feeling very bitter at having wasted an hour and a half.

I'm sure it's safe to assume we've all had this trouble at one time or another, ever since they started using small in-set circuit breakers. I remember having had the same problem in an old Raytheon set, years ago. Half a day checking for nonexistent intermittent shorts, and it turned out to be a bad circuit breaker! When a circuit breaker kicks out, there are two possible causes: an intermittent short in the power supply, or a breaker that won't carry its rated current.

A very simple gadget will give a fast, reliable circuit-breaker analysis and eliminate half the problem right away. The same device can also speed the isolation of real troubles in the power supply. So, I decided to build a "black-box" breaker checker.

Each breaker has two important ratings: the hold current, which is the amount of current that the breaker must carry without opening, and the break current. The table shows a list of breakers used in US TV sets and gives the correct hold and break ratings for each. This is all we need to know.

I made the astute observation that to read ac, I needed an ac ammeter. (How about that!) Since ac ammeters are scarce in TV shops (they're used mainly by electricians) I got one (0-5 ac amps) and put it in a metal meter box with banana jacks on the top.

This accomplished, I could open one of the leads to the breaker, hook the meter in series with it, and read the actual current being drawn by the set. When this reading is normal and the breaker still kicks out, there's got to be something wrong with the breaker. To find the normal current, simply check the hold-current rating of the breaker as shown in the table.

With the same meter, it's also possible to check the power supply: either the B+ supply current, or—by putting the ammeter in the primary—the overall currents drawn by the set. In the B+, this is invaluable for catching such troubles as leaky filter capacitors, current overload from the horizontal-output tube, and so on.

The box also is invaluable for checking power transformers. Put the ammeter in the primary, pull the low-voltage rectifier (or fuse) and unhook the filament winding on one side—in other words, disconnect all normal loads. If the transformer draws more than a fraction of an amp (iron-loss current is usually less than 0.1 amp), it's internally shorted. A genuine internal short will draw several amperes, so there's seldom any doubt about it. Takes only a minute compared to the half hour or more you'd spend waiting for the transformer to burn and send up smoke signals.

As usual, there are several possible metering techniques. Triplett has an adapter (model 10) which fits the model 310 pocket voltmeter, transforming it into a "clamp-on ammeter." The adapter is a current transformer with a hinged core which is opened and clamped around either one of the leads in the circuit. (If you get both of them, the fields cancel and you get no reading at all.) This type of meter is handy—if you make a lot of current measurements—because it reads by induction and doesn't require breaking the lead to measure current.

There's a third simple way to read breaker and primary currents: the "Ohm's Law Special." (This is the technique I actually used to check the breaker in that color set; at that time, I didn't have an ac ammeter either!) Put a 1-ohm resistor in series with the circuit, hook a 0-3-volt ac meter across the resistor, and read currents up to 3amps directly. This is an automatic Ohm's-law computer. One volt equals 1 amp through 1 ohm, or E=IR (see drawing in Fig. 1). The accuracy of this technique is as great as that of the resistor used and the accuracy of your voltmeter. The standard 5- and 10-watt replacement-type resistors are usually very close to rated value, and the shop voltmeter is usually accurate enough for practical work.

Any of these three methods will do nicely for home servicing and in-the-set checking, but an additional "black box" was needed to make a full check on a breaker, for both hold and break current. This means some kind of ac supply using any of the three meter circuits as an indicator.

The ac power line looked good until Ohm's law sorta caught my attention: 5 amperes at 117 volts calls for an adjustable resistor at a rating of 500 watts or more. So that was out! There's an old adage that says "To cut down on the watts fast, cut down on the volts." On the shelf was a filament transformer offering 12.6 volts at 2 amps, center-tapped. That'd do nicely.

There was one more important thing. I've learned over the years that the pro's won't build a gadget unless it meets two qualifications: one, it must be useful, save time, or do some job that conventional test equipment won't do.
I worked up a 2-ohm 25-watt resistor in series with the breaker cooled things down a lot, but the controllable-current problem still had to be solved. First thought was an adjustable resistor in the secondary, but Ohm's law got out of hand again. Five amps at 12 volts is 60 watts, and I'd need a 20-50-ohm pot with a 75-watt rating. That was out.

Well, put the pot in the primary, where the current isn't as high as because of the higher voltage. Then the pot won't have to carry all of the primary wattage—most of it will be across the transformer primary. This approach worked. I used a 1,000-ohm 10-watt pot and got the control range I needed.

Fig. 2 shows the schematic of the completed gadget. You can use any kind of current indicator you want because all the box does is furnish the current. I used one of the hot leads as common, the center taps as 6 volts and the other hot lead as 12 volts. Works out in practice like this: You can use the 6-volt range for low-current breakers, say up to 2.5 amps; for the bigger ones, 2.5 to 5 amps, use the 12-volt supply.

You can build this in any kind of case you want. A local tinsmith made the one shown, out of aluminum. You can make it in any shape or add anything you want to it. You can put the 2-ohm resistor inside the case and the meter jacks on it—any way, just so it works. I almost mounted an old crystal socket on top of the case, since it turned out to be an exact fit for the terminals of a new breaker. But, that would have been gilding the lily in a way, so I refrained.

One more thing. You may be wondering why I talk about drawing 5 amps from a 2-amp transformer, eh? Does sound a little rough, but if you consider that the principle of "temporary massive overloading" is used in TV design to a much greater extent than we generally remember, it's okay. Compute the actual wattage of a horizontal output tube during its conduction period, for example. It comes out something like 1,500 watts! The only way the poor little tube can take it is to be pulsed—it carries a simply tremendous overload for just a few microseconds, then they let it rest for a good while.

So, this is what I'm doing, but with slightly longer pulses. We can make tests up to 2–5 minutes at a 100% overload without getting anything too hot. We can thus check 5-amp breakers with a 2-amp transformer and a comparatively small adjusting resistance. In testing the gadget, I let it run for 3 minutes at 4 amps, and it didn't get too hot. Also, our only long-run tests are for hold currents down in the 2–3-amp range. The higher values for checking 3.75-amp units for their break-current levels are needed for only a second or two.

If you're really conservative and happen to have an old TV-type power transformer, use it—the 6-volt winding will probably have a rating as high as 8–10 amps. Use a chunk of iron like that, and it'll sit there all day without getting warm.

The parts we used are shown in the parts list along with their approximate costs. Use any kind of appropriate substitute you want. Surplus is a good source for heavy-duty potentiometers, etc., if you have a nearby store. However, the parts we used are all standard, everyday stock and ought to be available everywhere. The 10-watt 1,000-ohm pot will probably be the most expensive single item.

One last note: You'll find an occasional breaker used in the dc circuits—beyond the rectifiers, instead of in the rectifier input circuits. Test them in the manner. You'll find they have lower current ratings than the input types, but the action is exactly the same. END

The power-supply box and the ac ammeter are used in series to check breaker operation.

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*Note: A few are off the chart.*
Digital-To-Analog Fundamentals

By IRWIN MATH

IN TODAY'S SOPHISTICATED WORLD OF electronic computers, automatic control systems and complex communication networks, many physical and electrical quantities must be measured and processed with electronics. At present, there are two ways for handling such information—the analog and the digital methods.

When the value of quantities such as temperature, fluid flow and illumination level change, they do so gradually and continuously. To measure such analog quantities, certain sensing devices—thermocouples, flow meters, and photocells, for instance—are used. The output of a thermocouple is a continuously varying voltage; there are no jumps or breaks between one point and the next. For example, Fig. 1 is a graph of the temperature variations during a normal summer day, as measured by a thermocouple calibrated in degrees F. Notice that the curve is smooth—all temperatures from the high of the day to the low have been recorded.

Fig. 1—Temperature on a summer day.

Fig. 2 a—Simple digital counting system. b—The output from the counting system.

Other values—such as the number of boxes on an assembly line or the number of automobiles passing a toll booth—are called digital quantities. They are composed of distinct, separate units, never varying continuously but always in discrete steps. The output of digital sensing devices such as electronic counters, proximity detectors or photoelectric relays are usually pulses or steps in voltage. Fig. 2 a shows a high-speed production line with a photoelectric counter, while Fig. 2 b illustrates the output of the photoelectric cell. Every time an object interrupts the light beam, a pulse is produced and the counter is triggered. This output, unlike the analog output, is abrupt. An increase in the number of items passing the photocell increases only pulse rate. Amplitude remains the same.

Digital-pulse information, unlike continuously varying analog data, is more easily processed in electronic devices. Flip-flops can quickly count pulses, digital computers can readily add, subtract, multiply and divide them; and punch cards and magnetic tapes can store them. It is therefore often desirable to convert analog information to digital signals. Many devices have been developed to accomplish this, and if you understand how analog-to-digital converters work, you'll know more about today's industrial measuring and control systems.

As an example, suppose it's desired to keep the temperature of a room at 75°F. Since temperature is an analog quantity, what's needed is a device to sense 75°F, to turn on a heater if the temperature falls or a cooling device if it rises. Fig. 3 shows the system. A bimetallic strip is used as the analog-digital converter. When the temperature is below 75°F, the strip bends up (the analog input) and the heater is connected in the circuit (the digital output). As the temperature rises, the strip slowly bends down until, at exactly 75°F, the contact is broken and the heater turns off. If the temperature should rise above 75°F, the bimetallic strip bends further down and turns on the air conditioner. Now the cycle reverses, the contact being broken when 75°F is reached. By varying the settings of either contact point, various temperatures can be sensed and controlled.

Most analog-to-digital converters are more complex than the previous example. Consider Fig. 4. In this circuit an analog input of 0–10 volts changes the bias on Q1 (an npn transistor), thereby varying emitter-to-collector resistance R2. This change in resistance varies the total resistance (R1 + R2) in the Q2 emitter circuit, altering the number of pulses per second produced by pulse generator Q2. As a result, each analog change produces a definite change in the number of pulses. Since fractions of a pulse cannot be produced, the output is a true digital signal.

Using this system, analog temperature information can be read out on a numbered display device. A thermocouple's output can be fed to the converter and the resultant pulses used to trigger illuminated numerals.

When an analog quantity has been put in digital form for processing and storing, it's often desirable to recover the information by using a digital-to-analog converter. The automobile tachometer is an example. Engine revolutions—analog data—are translated into digital form by the breaker points, which produce pulses used to fire the sparkplugs. A dc meter is used to indicate engine rpm, but the meter can't respond to pulses. It needs a dc voltage, furnished by the circuit of Fig. 5.

An input pulse causes C1 to charge through D1 with indicated polarity. While this happens, D2 is reverse-biased and therefore nonconducting. After the pulse has passed, the voltage on C1 reverses-biases D1 and discharges through
D2 (which is now forward-biased). C2 charges until the voltages across both capacitors are equal. The next input pulse causes exactly the same sequence of events, adding more voltage to C2. But meter resistance Rm is in parallel with, and constantly discharging, C2. As a result, the meter indicates the average voltage across C2. The faster the engine turns, the more pulses per second are fed to the circuit, the more quickly C2 is charged, and the higher the meter reads. Thus meter indication is proportional to engine speed.

The preceding examples are employed in certain simple devices but have limited application in industry and communications. More complex systems, combining several functions, are used extensively for special applications.

Figs. 6 and 7 are simplified diagrams of a telemetry system used to obtain fuel-tank information from a rocket in flight. All values to be measured are analog, so the sensing devices produce continuously varying output voltages, each proportional to the parameter being measured. One important item is the rate of fuel flow. To sample the flow, a paddle wheel in the fuel line drives the armature of a dc generator (Fig. 6). Hence, the dc voltage is proportional to the rate of fuel flow.

It's also desirable to know how much fuel remains in the tank at any time. The task is accomplished with an unusual capacitor. Again referring to Fig. 6, a rod is suspended in the middle of the tank, forming one plate of the capacitor. The walls of the tank form the other plate. The value of this capacitor is determined by the dielectric constant of the liquid (which is known for each fuel type) and by the amount of liquid in the tank.

Since the capacitance is very small, special techniques must be used to measure any change. The tank capacitor is placed in series with an external fixed-value capacitor, forming a voltage divider. An ac generator places a voltage across this divider so that any change in the value of the tank capacitor changes the ac voltage amplitude. This ac output is rectified to produce a dc voltage for further processing.

Resistive voltage dividers fed by dc sources are used to measure fuel temperature and pressure. One divider contains a thermistor in the tank, monitoring the temperature and varying dc output voltage proportionately. Fuel pressure is measured by a carbon block between two metal plates in another voltage divider. Any increase in tank pressure compresses the carbon material, altering the output voltage.

The output from each sensing device is tapped down to a convenient range for conversion to digital form. It would be desirable to monitor all parameters continuously, but only a single transmitting channel is available; consequently, time multiplexing must be used. Switch S1 connects each sensor output to the converter for a short period, then moves on to the next one.

The analog-to-digital converter operates just like the one shown in Fig. 4. Its pulse output—which is proportional to the quantity being measured—is fed to a pulse modulator. This stage modulates the transmitter of the rocket, which sends the telemetry information to the receiving station. Note the sync inserter—this device adds a sync signal to furnish a reference point for locating the position of switch S1. Thus at the receiver it's possible to determine which quantity is being measured at any time.

Fig. 7 shows how the telemetered information is processed by the receiver. Rf is processed by a conventional method, and a pulse detector recovers the original pulses. These pulses go through the digital-to-analog converter, and the continuously varying dc output is fed to sampler S2, identical to and synchronized with S1 in the rocket. S2 feeds the analog data to the various indicating meters, which are calibrated in gallons per second, pounds per square inch, etc.

For permanent reference, a tape recorder stores the pulse information. At any later time, the tape may be played back and used to drive the converter, S2 and the readout meters.

For greater resolution, sometimes the pulses are fed directly to electronic counters with numerical display readouts. At other times the analog outputs of S2 are fed to oscilloscopes or inkchart recorders.

The system described in Figs. 6 and 7 is necessarily simplified; most systems are more complicated and sophisticated. However, the same basic principles are employed in both.

There are many other types of converters and sensors—time encoders, shaft-angle decoders and weighted decoders. All accomplish similar tasks. A continuously varying quantity is monitored by a sensor, the information changed to pulses, and these pulses used to control some portion of a production process. For human monitoring of the quantity, the pulses are converted back into continuously varying voltages, where they drive meters.

Digital and analog systems are like two languages. The converters are really translators. They're useful because two different systems can then exchange information. It's a lot like two persons from different countries talking to each other through an interpreter. Without him, there'd be no communication.
Lucky Hunts Horizontal Hold

The intrepid and youthful benchman chases trouble like an overcontrolled oscillator seeking a 15,750-Hz point in phase with the signal.

By WAYNE LEMONS

Lucky was puzzled, a not unusual situation. His boss, Cy, was out helping in some civic venture and Lucky was left to find the reason for a "no horizontal hold" complaint. The receiver was a Zenith 16C20 chassis. The picture wouldn't lock within the range of the back-panel control. After pulling the back, Lucky noticed the control was a slug adjustment. By putting out the adjustment knob so that it missed the stop he could turn the slug. Turning it past the stop produced a locked-in picture.

"The boss sure made a boo-boo on this one," he said to himself. "I wish he was here so I could show him."

If Lucky rubbed Aladdin's lamp he could not have had his wish granted more quickly. Cy, stomping the snow off his shoes, plunged through the door.

"The committee decided it was a little too blustery to decorate the Christmas tree on the courthouse lawn," he explained before Lucky could ask.

"I can guess who the chairman of that committee was," Lucky grinned. "I just thought you might need some help with that Zenith."

"Me?" Lucky asked in mock surprise. "Me, the old pro?" He did an elaborate bow and swung his open hand toward the receiver. "Just look at that . . . that . . ."

Cy couldn't help laughing at the look of consternation that crossed his young helper's face. The picture on the set was out of horizontal sync. Lucky dived for the hold control and after some frantic juggling eventually got the picture locked in again.

"Critical, ain't it?" Cy noted.

"A little," Lucky admitted.

"Had to move the hold control past its regular stop to get a picture at all, right?"

"Then . . . then . . ." Lucky began to comprehend, and threw up his hands as if resigned to his fate. "You balanced a trap and I put my foot in it as usual. You tried pulling out the knob and turning it past its stop, then you deliberately put it back where it was, just to catch me. When the picture locked in, I thought the trouble was fixed."

"That's a lesson you have to learn if you ever want to become a good technician. Always check the cause and find the cure if at all possible. Remember that treating the symptoms doesn't usually cure the disease."

"But it seemed to lock in okay," argued Lucky.

"Are you sure? If you had taken the time just to change from one station to another, you'd have seen it wouldn't hold."

"Is that a good way to check horizontal sync?" Cy asked. "Right," Cy said. "Or you can just switch off channel and back on. Anything to shock the circuits. If the horizontal is working okay the picture should look in immediately with no slanting bars."

"And if it doesn't?"

"Then try setting the horizontal hold until it will."

"And if that doesn't work?"

"Then dig in and find the trouble." Cy grinned.

"I suppose that's what we have to do here."

"Right," agreed Cy. "I checked the oscillator tube this morning and even replaced it with another one. I did the same to the sync tube, so I'm sure it's circuit trouble. Where's the schematic?"

"Lucky didn't answer. He started digging through the service literature files. He came up with the diagram and spread it in front of them. They both studied the circuit of Fig. 1 a minute. "What kind of an oscillator is that?"

Lucky asked.


"Well; even I know that! What I want to know is how it works?"

"Pretty good. Most Hartley's do."

"You know what I mean," Lucky fumed. "Explain the circuit, the whole circuit and nothing but the circuit."

"Oh," said Cy with feigned innocence. "Well, look at the schematic here. The control circuit uses these two diodes and the tripole half of the 6E8 as a reactance tube. The oscillator . . ."

"Looks like an electron-coupled job," Lucky interrupted.

"It is, with a slight difference from the run-off-of-the-mill eco."

"What's that?"

"Well, as you know a Hartley puts out a sine wave."

"And they don't use sine waves to drive sweep circuits."

---

The receiver worked fine until it was switched to another channel. This is what it looked like after switching channels.

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Fig. 1—Heart of the problem, Lucky found, wasn't in the tubes, but in the circuit of the horizontal oscillator and control of this Zenith 16C20 chassis. Can you find the trouble?
"Bravo," said Cy, "maybe some of that fog in your head is clearing away after all. How do you suppose they get the modified sawtooth then?"

"From the plate circuit?"

"Right. Zenith calls this section of the tube a horizontal oscillator and discharge, as you can see. The .0015 capacitor and the 18K resistor in series make up the discharge or wave-shaping network in the plate circuit.

"I see that, I think, but what about the control part of the circuit? That must be where our trouble is."

"You're probably right," agreed Cy. "You savvy how the diodes work, right?"

"Well, at least I know that they put out a negative or positive voltage depending on whether the oscillator is high or low in frequency as compared to the sync pulse.

"That's true," said Cy. "In this circuit, the control voltage is then fed to the grid of the horizontal control tube."

"Then the control tube amplifies the control voltage?"

"Well, yes and no. There is amplification and it is utilized, but you see this tube isn't dc-coupled to the oscillator as in some circuits. And it does make a difference, you see."

"I see that," said Lucky. "There is a 470-µF coupling capacitor from the plate circuit to the oscillator coil, though."

"Right. And that puts the control tube right across the oscillator coil in series with that 470 µF. See that? Now what happens if we change the bias on the grid of the control tube?"

"That will put more or less capacitance across the oscillator coil because the tube will act as a variable resistance in series with the 470 µF across the oscillator coil."

What's the voltage between A and B?—John A. Reeder, Jr.

Conducted by E. D. CLARK

Three Zener diodes, each rated at 3⁄4 watt, are connected as shown to expand a voltmeter scale. What's the voltage between A and B?—Kendall Collins

Two puzzles for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to this month's puzzles are on page 91.
FUEL CELLS—
Power for Tomorrow

Electricity from chemical power packages

By ALLEN B. SMITH

The recent announcement by Ford Motor Co. of a significant development in chemically produced electricity is one more step in an industry-wide effort to develop self-contained, efficient and economical sources of clean power. Spurred on by government projects for spacecraft power, industrial quests for new products and private concern over air poisoning, the fuel cell is enjoying new popularity in labs across the nation.

Just what are fuel cells? How are they constructed, and are they as efficient as other sources of energy? Is there a future for chemically generated electricity? If so, where does that future lie?

For years, researchers have known the answers to all but the last question. But a lot of us are still pretty much in the dark about the what's, why's and how's of the fuel cell, in spite of the fact that as early as 1839 an Englishman named Sir William Grove outlined its theory of operation. Nearly 100 years later, in 1932, another Englishman, an engineer named Francis T. Bacon, put Grove's theory to work and began developing practical cells of high efficiency. Since that time, the fuel cell has progressed from obscure lab-curiosity research to the crash-development program that has caught the attention of the entire technological community—and the general public.

Before we speculate on the return of electric cars and other vehicles, on fuel-cell-powered space stations, on lightweight portable military power packs, or on homes in which all energy comes from their own private source, let's find out just what we're talking about.

The fuel cell resembles an ordinary battery in many ways; its main difference is that it doesn't require recharging. When the chemicals that make up the fuel cell react, free electrons are liberated, and a voltage is developed between the cell's two electrodes. All that is necessary to sustain this voltage—and the resulting current flow—is a continuing supply of the chemicals.

Another startling fact is that fuel-cell efficiencies theoretically approach 100% (present cells attain nearly 75%) as opposed to efficiencies of 40% for modern steam generating plants and 25-35% for gasoline and diesel engines. These characteristics give a strong indication of what all the excitement is about.

Basic fuel-cell theory

In principle, any reduction-oxidation chemical reaction can develop measurable electrical outputs. Even the most highly developed fuel cells employ hydrogen and oxygen, generally in their gaseous states. Both elements are easily available, and their only byproduct is pure water. Potassium hydroxide is the most common cell electrolyte, although acid electrolytes may be used. This type of cell is quite basic, and lends itself well to explanation of the chemical process involved.

The action of a fuel cell is often described, although not absolutely accurately, as the inverse of simple electrolysis of water. In electrolysis, as you may recall from your experiments in school, a voltage is applied to electrodes immersed in water made conductive by adding common table salt. Current flows, and electrolytic action produces pure oxygen and—within the solution of water and salt—hydrogen ions and hydroxide ions. Much hydrogen is produced commercially in this manner.

In the fuel cell diagrammed in Fig. 1, hydrogen is fed under slight pressure to the fuel electrode (anode). Individual hydrogen molecules pass through the anode to collect and combine with hydroxide ions. A catalyst (usually platinum) on the electrode speeds the reaction and the release of electrons. Free electrons on the surface pass into the electrode and are conducted up through it and through the external load to the oxidant electrode (cathode).

Oxygen fed to the cathode under pressure is broken down in the electrode, and oxygen molecules collect on the electrode surface exposed to the electro-
lyte. There, the oxygen combines with water and with the electrons which have flowed from the load circuit, producing hydroxide ions. These ions migrate to the fuel electrode, completing the circuit chemically and electrically. Output of typical hydrogen/oxygen cells ranges between 50 and 200 amps at 0.7 to 0.8 volt/sq ft of the cell area.

The simple cell doesn’t tell the entire story of fuel-cell chemistry or system operation. With research activity quickening, diverse techniques have been developed. Various fuel/oxidant combinations, electrolyte compounds, methods of containing the electrolyte, operating temperatures and pressure systems are all covered by the fuel-cell label.

Low-temperature cells

The largest group—and by far the most successful to this point—consists of the hydrogen/oxygen (hydrox), hydrogen/air (hydair), and some alcohol/air cells, all of which operate at fairly low temperatures, generally under 100°C. Some secure their fuel and oxidant gases from pressurized containers; others, notably the cells developed for space vehicles, use cryogenically stored liquid hydrogen and liquid oxygen (LH2). Still others use liquid oxygen with the fuel from pressurized containers.

The solid-hydrogen oxygen (S-HO) system consists of a hydrogen generator and a standard fuel cell stack. The hydrogen generator is connected to the fuel cell stacks in parallel. The generator operates off the fuel cell power and provides additional fuel when needed. The generator is an electrically driven fuel cell, and the fuel cell is an electrically driven hydrogen generator. Both systems are designed to operate in parallel, with the hydrogen generator providing additional fuel when needed. The hydrogen generator is connected to the fuel cell stacks in parallel, and the fuel cell is connected to the hydrogen generator in series. The system is designed to operate in parallel, with the hydrogen generator providing additional fuel when needed. The hydrogen generator is an electrically driven fuel cell, and the fuel cell is connected to the hydrogen generator in series.
search & Engineering Co.) which uses sulfuric acid as the electrolyte, and the direct propane/air cell that uses very expensive platinum electrodes and a phosphoric-acid electrolyte. Still in early stages of development, these latter two techniques have not as yet been fully evaluated.

Medium-temperature cells

In this category, the outstanding techniques and hardware items are those descended directly from the 1932 experiments of Dr. Francis T. Bacon, Pratt & Whitney Aircraft, Div. of United Aircraft, has modified the Bacon-type cell—basically, a hydroxcell with fuel and oxidant supplied at elevated pressures—to operate with a potassium-hydroxide electrolyte at temperatures near 200°C with fuel pressures of 1 to 5 atmospheres. Under these conditions, the cells produce 250 amps at 0.85 volt/sq ft, giving about 70% efficiency. The pure nickel electrodes contain no precious-metal catalysts. They rely instead on the elevated temperature of the electrolyte to provide the increased molecular action that ensures rapid chemical reaction. This cell is the one being readied for use in NASA's Apollo spacecraft development program.

Also in the moderate-temperature category are most of the cells using liquid and gas hydrocarbon fuels with some form of oxidation or reforming system to break the basic fuel into useful hydrogen gas. Several types of cells use palladium/silver membranes, which are permeable only to hydrogen, to extract hydrogen directly from hydrocarbon fuels. They operate at 350° to 450°C. The exchange of ions through the membrane into the potassium-hydroxide electrolyte is speeded by nickel-screen catalysts and superheated steam. In most of these cells, pure air is the oxidant, rather than pure oxygen. Leesona Moos Labs, Pratt & Whitney Co., Westinghouse Research Labs, and General Electric Co. are testing several electrode materials and configurations, as well as complete hydrocarbon/air fuel-cell systems.

High-temperature cells

The use of molten-carbonate electrolytes in voltage-producing cells has been investigated by researchers at Texas Instruments, Inc. and at the Institute of Gas Technology in Chicago. This family of fuel cells has many attractive characteristics, including low cost, silence, high efficiency and adaptability to various fuels.

Typical of this class of cells is one under development at the Institute of Gas Technology, which uses the electrolyte a mixture of two or three alkali-metal carbonates and an inert-metal oxide. The electrolyte compounds are prepared and mixed initially in powdered form, then hot-pressed into disks at pressures of 8,000 psi and temperatures of 950°F. During operation, cell temperatures are held at 1,000°F to 1,100°F, either by action of the process itself or by external heat. At this elevated temperature, the electrolyte melts. The molten electrolyte is held between a silver-film cathode about 10 microns thick and a porous fiber nickel anode.

Fuel for the cell is natural gas, processed by steam reforming in the presence of a catalyst to release hydrogen; the oxidant is ordinary air. Efficiency of this cell depends on a variety of factors, but primarily on the efficiency of the external hydrogen reformer and the rate at which oxygen from the air is combined in the reaction. Overall efficiencies range from 40% to 43% with cell potentials of 0.7 to 0.9 volt.

Where from here?

It should be clear by now that much of what you have read so far in this article and in others has concerned primarily the development of fuel-cell devices. To be sure, there are practical units in operation, but they are primarily in high-budget NASA or Air Force spacecraft projects. None of the existing systems can be regarded as commercially feasible at this stage of development. In spite of this, potential fuel-cell applications don’t seem to have been exaggerated.

There are several commercial uses for which fuel-cell power is being considered: industrial, especially in metallurgical processes; vehicular drive systems; portable power for electrical and electronic equipment; and energy centers for homes. Of these, vehicular and portable power seem most likely to offer specific advantages over present means. As long ago as October 1959, Allis-Chalmers’ research division demonstrated a fuel-cell-powered tractor capable of exerting a 3,000-lb drawbar pull. The power unit was a hydro-cell matrix generating 15 kW. Since that time, the same company has demonstrated vehicles using hydrox, ammonia/oxygen, and hydrazine/oxygen fuel-cell packages. Among these have been a fork-lift truck with 4,000-lb capacity, a two-man golf cart, a lightweight fork-lift truck of 2,000-lb capacity, and other related vehicles.

Under contract to General Dy-
nynamics' Electric Boat Div., A-C also designed and assembled a 36-volt system to supply 750 watts of power for the electric drive motors of a one-man underwater research vessel, the first practical application of fuel-cell motive power. The craft (RADIO-ELECTRONICS, August 1966, page 32) used a power pack supplied by liquid hydrazine-hydrate fuel and gaseous oxygen under pressure in rapidly rechargeable cylinders. Fifty individual cells made up the series-connected module. It had output taps at 12 volts for communications equipment and 24 volts for vehicle subsystems, and used the full 36 volts for the main propulsion motors. Individual cells produced 250 amps/sq ft at a voltage of 0.75.

**Fuel-cell power for cars?**

The question of whether fuel-cell systems will power cars, motorcycles and boats of the future hasn't been fully resolved. The odds are strongly in favor of the affirmative. It's no secret that major automotive research labs in the US and Europe are working toward fuel-cell power packages for small-sized personal vehicles for use primarily in metropolitan areas.

Ford's liquid-sodium/sulphur rechargeable battery, mentioned at the start of this article, is not a fuel cell using expendable chemical components; but it does represent a significant development in compact, lightweight electrical sources that can deliver the high-current demands of an automobile drive motor. Strictly a rechargeable battery, Ford's device uses techniques developed in fuel-cell research. It probably is an interim step in the development of an actual fuel-cell power pack.

The Ford cell employs liquid sulphur as the anodic element, a ceramic electrolyte that is permeable only to migrating sodium ions, and a liquid-sodium cathodic element. In developing electricity, the sodium atoms give up electrons to the external circuit through the cathode. The resulting sodium ions pass through the ceramic electrolyte to form sodium sulfide in reaction with the sulphur and the free electrons returning from the load through the anode. Recharging is with a 117-volt rectifier/charger.

Ford spokesmen report that within 2 years it will be possible to construct a 1-kW unit weighing about 100 lb. This power source could drive a 1,100-lb vehicle carrying two adults and two small children at 40-50 mph up to 200 miles. Prototypes are now being constructed and tested in England.

Why all the hue and cry for electric cars? Probably, the growing realization that our cities are being poisoned by the hydrocarbon byproducts of gasoline and diesel-engine exhausts. Legislators and private citizens alike are pressing for solutions and for action. Since a fuel-cell-powered car would create no byproduct but pure water, the fascination is obvious. Additional advantages of electric vehicles are silence (noises levels in metropolitan centers cause widespread concern), rapid acceleration to cope with city traffic, and greater efficiency.

In spite of these advantages, fuel-cell technology still has a long way to go before manufacturing costs reach acceptable levels. At this point, it appears that 10 or more years will pass before you can buy an electric car. Don't, however, underestimate the extraordinary achievement of which American ingenuity is capable when supplied with a vigorous flow of the long green for intensive research on a broad scale. And keep an eye on that ever-darkening yellowish-brown cloud over your cities: that cloud may be the catalyst that will speed fuel-cell power into your life. Unless an unforeseen breakthrough occurs in the development of lightweight, low-energy nuclear-power sources, the fuel cell in various forms is destined to become a familiar power source of the future.

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**HI-FI, HI-FI, ALL AROUND THE HOUSE**

How to have stereo speakers, volume controls and on-off switches in every room

EveV wish you could have stereo in your bedroom? Fine—but what do you do when you're in the living room? It's expensive to have a separate installation in each bedroom, and moving a large system is out of the question. And what if you've got several bedrooms full of people who might want to listen at the same time? You might also want music in a playroom or patio.

The solution—which is nothing new—is to install speakers in each room, using separate volume controls for each speaker pair. One problem remains: Who wants to get up late at night, after listening to dreamy music, and walk downstairs to turn off the power? A clever technique was used to overcome this problem in one of the neatest jobs we've seen. It's a six-station stereo installation at the home of Sheldon J. Tannen, Westhampton, N. Y. It was installed by George Nicola, of Atlantic Hi-Fi & TV, Moriches, N. Y.

Fig. 1 shows the wiring of the left-channel speaker bus. All but one of the speakers are in series with L-pads (Centralab WL-8) to permit individual volume control. The monitor speaker is in the living room by the amplifier. Note

![Fig. 1 — Wiring diagram of left-channel speaker bus which runs from room to room throughout house.](image-url)
that Bedroom 1 has an extra component—a closed-circuit phone jack. Most of the time the speaker is used, but if one person in the bedroom wants to listen to music while the other is asleep, the phones are plugged in, muting the speaker simultaneously.

Of course, the wiring of each channel is identical to that of the other, and the right-channel L-pads and jacks are ganged with those in the left channel.

Heart of the system is a Fisher 400 FM-Mx stereo receiver, preamplifier and power amplifier, together with a tape cartridge machine (see photo). The 10-element FM yagi mounted on the chimney is aimed toward New York City. The lead-in is 300-ohm marine-grade stuff, for long life under salt spray. (The house is at the water’s edge, on an inlet from Long Island Sound.)

Amplifier speaker output is fed between the house walls at 8 ohms impedance, since speaker runs aren’t long.

What makes this installation different from others is the ability to turn the system power on and off at each remote station. Furthermore, only three-conductor wiring is used between remote switches, and all switches are in parallel. Fig. 2 illustrates the remote switching. The relay is a split-coil type used in residential wiring for remote control of nearly any small appliance. The relays are available with various contact ratings, to handle light- or heavy-current loads.

Each remote switch is a three-position spring-return type, with a normal-center position. When a remote switch is thrown to the ON position, the relay ON coil snaps the contacts together, connecting the ac line to the amplifier power transformer. The remote switch returns to center (off) but the ON coil in the relay latches. When a remote switch is then thrown to the OFF position, the relay OFF coil snaps the contacts open, breaking the ac circuit to the amplifier power transformer. The OFF coil also latches, and again the remote switch returns to the center (off) position.

There is at least one particular convenience to the system. Suppose A and B are each listening to stereo late one night, but in separate bedrooms. When A is ready to go to sleep, he turns down his volume control and uses his remote switch to turn off the ac. But B wishes to listen a while longer. When the ac to the amplifier goes off, he simply turns it back on again.

The speakers are flush-mounted in either the walls or ceilings in the bedrooms and playroom. The patio speakers are Atlas outdoor trumpets and the living-room speakers are Scott bookshelf models.

**Fig. 2—This control diagram shows the secret of how the remote on-off switches work.**
Technician to Technical Writer

Upgrading yourself from maintenance and repair to writing about it is a change worth considering

BY FRED W. HOLDER

SINCE THE BEGINNING OF WORLD WAR II, there have never been enough skilled technical writers to meet adequately the growing demands for published technical data. Aerospace industry forecasts for the next 5 years show a need for 30% more technical writers. If aerospace is any indication of industry in general, another 20,000 to 30,000 technical writers will be needed in the next 5 years.

In August 1961, I was a $100-a-week electronic technician with General Dynamics Electronics in San Diego, Calif. I left GD to take a job as a technical-writing trainee in Los Angeles. My training and experience as a technician really paid off. In 4 years I doubled my earnings and progressed from trainee to supervisor of technical writing.

Is there a place for you in technical writing? If you want to work in a professional atmosphere with higher earnings, technical writing could be good for you. It offers: (1) many of the challenges of the engineer’s job, without requiring an engineering degree; (2) the professional benefits enjoyed by the engineer, and (3) a salary comparable to an engineer’s, when you consider the difference in educational requirements.

A recent survey conducted by Gerard J. Ennis, a captain in the U. S. Air Force, shows that the salary range for technical writers working in the aerospace industry varies from about $4,500 to more than $9,000 annually. I know several technical writers who make $10,000 to $12,000 each year. Only a few years ago these same fellows were electronic technicians making $2.50 to $3.00 per hour.

Jim Lineback is an ex-technician, presently employed as a technical writer. I asked Jim what his electronics background was when he entered the technical writing field.

“I was a Navy sonarman. That’s where I first learned electronics. Later I became a radio and television techni-

Jim Lineback checks his manuscript.

Development of a technical document.

ician in Cleveland, Ohio. I didn’t want to do radio-TV repair for the rest of my life, so when I had an opportunity to go with Burroughs Corp. as a field service technician, I took it.”

Burroughs sent Jim to a seven-month training school, where he had his first contact with industrial electronics and digital computer technology. After training he was sent to a field location where he did service work on Burroughs equipment. Jim found field work required a lot of traveling. “At least,” he said, “in field service I made considerably more money than I could as a technician working on such things as radio and television receivers.”

“What attracted you to technical writing?” I asked.

“After 3 years of traveling all over the country for Burroughs, I wanted to settle down somewhere and have a regular eight-to-five job with the opportunity for more pay and somewhat more prestige. Technical writing is a white-collar, semiprofessional type of work with considerably more status than I had as a technician. I think we work on a level almost similar to that of an engineer.

“After leaving Burroughs, I eventually moved to California where I was hired at Honeywell, Inc., as an associate technical writer. Now, after about 4½ years, I’m up to senior technical writer.”

As a technical writer with Honeywell, Jim writes about new computer-controlled training devices for the Navy. He learns the overall system operation through his association with the design engineers and from researching engineering documentation such as schematics, assembly drawings, wiring lists and diagrams, and engineering reports on the system. With the research completed, Jim writes handbooks for use by the technician who will operate and maintain the system. He sees the job through from outline to printed document. He works with technical illustrators to develop illustrations for the document, and

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coordinates the production typing and printing of his writing efforts. His electronics training and experience are valuable when he is writing alignment, calibration or troubleshooting procedures.

Jim has worked on three large training devices since he joined Honeywell in 1961. Two of them were Fleet Ballistic Missile (FBM) submarine attack trainers; one at New London, Conn., and the other at Charleston, S.C. His most recent assignment has been to write the handbooks and training course materials for an Anti-Submarine Warfare (ASW) Helicopter trainer installed at San Diego, Calif.

In addition to writing handbooks for training systems, Jim also works on proposals for new contracts, and edits and publishes engineering reports.

"What has been your most interesting assignment as a technical writer?" I asked.

"The New London FBM submarine attack trainer. It was so complex it presented quite a challenge. I had worked on a fairly large system with Burroughs Corp. as a field-service technician, but that had been vacuum-tube data-processing equipment. The New London trainer was all solid-state. It also had many types of subsystems: analog, digital, optical, etc. It was quite an experience; I enjoyed it."

"Do you think a technical writer gets to learn more about a system than the technician who maintains it?" I asked.

"There's no question about it. As a technician, I think, just a general knowledge will take you a long way toward fixing troubles in a system. The writer, on the other hand, has to dig deeper into the individual components of a system and gain a much more thorough understanding of system operation before he can write a book about the equipment, telling in detail how the equipment works and how to fix it. The system knowledge you have to gain as a technical writer would, if you were a technician, make you a top-flight technician on that system."

"What part of technical writing do you find most interesting?"

"The researching, the process of finding out what makes the system work. When you're faced with learning the details of a complex system, there is a real challenge. This is probably the thing that appeals to most writers with a technical background. In essence, it's finding out how the system works and then getting it into words. Then, of course, you have the satisfaction of seeing your words in print and knowing you have put out a manual that may help somebody out in the field, maybe a technician like you used to be."

"Along the same line, what do you think is the least interesting part of technical writing?" I asked.

"Oh, the somewhat dull, but important, mechanical chores that have to be done to get a document out. But that is really only a small percentage of the total job. Things can get pretty hectic as you try to meet a deadline and still stay within costs."

By mechanical chores, Jim means all the things that must be done after a manuscript is written to get it ready for publication as a printed document. This represents: (1) preparing a list of illustrations and deciding how much of a printed page each illustration will require; (2) checking that all paragraphs are numbered correctly and that all paragraph references are correct; (3) checking all illustrations and tables against the text to make sure they are referenced correctly; and (4) making up a dummy book showing the layout of written material with respect to tables and illustrations.

"You mentioned earlier that when you left field service you were looking for an eight-to-five job. Have you found technical writing to be this kind of work?" I asked.

"Well, it hasn't been entirely that way. There has been a fair amount of overtime to meet deadlines, so it hasn't always been an eight-to-five job. Also, I had to go back to New London to work on one project and spent almost 5 months there rewriting and verifying publications. Even so, I think I did achieve the main thing I was after, to settle down in a community and live a rather stable life."

"Do you feel there is room for more qualified technical writers?" I asked.

Jim laughed. "Yes! Generally speaking, it's very hard to get qualified people. I suppose this is true in any occupation, but it's especially true in technical writing."

"What is a good technical writer?" I asked.

"The best is a qualified writer with a good technical background. There are certain things in technical writing that a skilled nontechnical writer can handle. But for the most part, I think the writer who has been a field-service or maintenance technician makes the best technical writer."

"What about college training? Are there any courses you could recommend for the beginning technical writer or the technician wishing to change over to technical writing?" I asked.

"Yes, I think such a person would have an advantage if he would take some courses in English grammar, mathematics, basic writing and, of course, basic and advanced electronics to keep him up to date on the latest in electronic devices. I started out as a trainee and learned on the job, even though I have no college training."

"Do you use mathematics much in your job?" I asked.

"Actually, in my day-to-day work, I don't use math very much. But there are times when a mathematics background would be of value. For example: In my present assignment on the ASW helicopter trainer, I needed a background in trig to fully understand system operation. Fortunately, I had a course in trig several years ago, but I had to bone up on it."

"Have you found the chance for recognition is better for the technical writer than for the technician?" I asked.

"Yes, as a technician you are more or less relegated to the background and your work is not always recognized as yours. As a writer you have the opportunity to be in the limelight. If your work is good, you are definitely recognized. Of course, if your work is bad, you are also recognized. I think this gives you a lot more incentive to put more effort into your job. I know I've never had quite the same feeling about any other occupation so far as trying to do my best. I knew individual recognition was there if I was willing to work for it."

"Didn't you win a company award
for your work at New London?” I asked.

Jim laughed. “Yes, the company held this Put Yourself in the Customer’s Shoe contest. Those who the company felt had contributed to successful relations with our customers were awarded a pair of Hush Puppies. I was lucky.”

Jim is typical of many technical writers presently working in industry. Writers with practical technical experience make the best writers of maintenance and operation manuals because they have a feel for what information the technician or mechanic needs. Jim is an example of how a technician with a desire to get ahead can do so in technical writing—even without college training.

College training is important, although it may not be a specific requirement. The ideal technical writer, of which there are very few, has a B.A. degree in physics or a B.S. degree in engineering with a master’s degree in creative writing, English or journalism. Many of the technical writers working in industry do have college degrees, but few meet the requirements for the ideal technical writer.

Many technical writing groups do original writing from their own research, as do Jim and other writers at Honeywell. In other organizations, the technical writer is really an editor, in that he edits, organizes and publishes material written by engineers. This technical editor generally has to have more formal college training in English, but doesn’t need as much technical training.

Some technical writers, like Jim, work in industrial organizations. Others work for government agencies, national news magazines, and technical magazines. There are also free-lance technical writers who write articles for the various trade and technical magazines. The freelance market is the most difficult to enter because it requires a good deal of study and contacts with editors and public relations men.

For the person desiring some of the freedom of the free-lance writer, there are companies specializing in technical publications who send writers to companies on contract for periods of a few days to several months. These operations are similar to the Kelly-girl service for stenographic help. Writers working on a contract basis are normally referred to as job-shop writers. Such persons earn higher hourly than a regular salaried writer, but they enjoy less job security. I might add, however, that the good job-shop writer is seldom out of work. In September 1964, I asked one of these fellows why he worked only 32 hours a week. His answer: “I earn $5.50 per hour and besides, I’ve already made $10,000 this year.”

END

Need A Power Resistor? Try A Transistor

By CLEMENT S. PEPPER

HAVE YOU DUG THROUGH YOUR JUNKBOX lately in a fruitless search for a much-needed power resistor? Naturally, the size you need is never there. More than likely you pushed a power transistor to one side while looking. Better go back and get it. A power transistor makes a first-rate variable load resistor, good for many uses.

A power transistor can be made to look like either a small or a large resistor. Just change the base input current. The collector voltage will adjust to any source within its ratings. To be safe, stay within one-half the rated collector-to-base breakdown voltage. A resistor in series with the collector will help.

In addition to the transistor you’ll need a flashlight cell, a resistor or two, and a low-resistance potentiometer. More than likely these are on hand.

The transistor will be more useful on a heat sink. Terminals for base, emitter and collector connections help avoid wasteful accidents. The small square of Masonite shown in the photo takes but a few minutes to make. It is much nicer to work with something that says put on the bench.

When you have your transistor all set up and ready to go, you will find it of value for other uses as well as for a power resistor. It is very handy as a series regulator when experimenting with power-supply circuits. Or you can make comparisons between different audio and servo-amplifier circuits. With two similar transistors experiments with push-pull output circuits are quickly made.

END
The Audio Man’s Audio System

Custom sound designed and built by the experts for use at their own conventions

By THOMAS R. HASKETT

Probably several hundred thousand PA systems are in use today. Many are poorly designed and inefficient, and few are really effective. Where would you find a really great PA system? At a convention of men in the audio business—the Audio Engineering Society.

The problem

Members of the AES are engineers and technicians working in sound recording, broadcasting, acoustics, language laboratories, electronics manufacturing, and even PA-system installation. When they gather for a convention, they need the very same device that many of them earn a living designing, installing and maintaining—a PA system. From modest beginnings and to meet their special needs, the AES has designed and fabricated a system that is probably one of the most up-to-date in existence today. It was field-tested at their October 1966 convention in New York City.

In early AES days—almost 20 years ago—they used existing hotel PA systems for conventions. Such systems, being designed as compromises to fit many needs, weren’t entirely suitable for the AES. By 1957, the Society decided to assemble its own system to fit its unique needs. There were three requirements:

1. The voice of the person addressing the convention had to be amplified so everyone in the audience could hear him.
2. Many of the technical papers delivered at a convention involved the presentation of recorded audio material on disc or tape. Such recordings had to be amplified and the signal fed to speakers so the audience could hear it.
3. All spoken material from the lecturer, questions and comments from the audience, and demonstrated audio material, had to be taped for the permanent files of the AES.

Partial solutions

Beginning with the 1958 convention, AES assemblies used a pool of equipment loaned by various audio manufacturers. A fine idea, but it had one disadvantage: The system had to be redesigned each year, depending on the particular gear loaned. Since the services of the console operators are donated by recording studios, each time the system was redesigned or a different console was used, time was lost. Each operator worked only a few hours during the convention total of about 60 hours, but considerable time had to be spent breaking the man in on the equipment operation.

Simplicity and flexibility became two key points in a desirable convention sound system. What’s more, at each twice-a-year convention, the equipment had to be set up in about 12 hours. Setting up a different system each year can be a slow process.

Somehow, the society managed for a few years, finding new ways to overcome old problems. Sometimes a hall had so much reverberation there was an unnatural sound in the rear seats. Low-level distributed speakers and a tape-delay mechanism driving rear speakers minimized this difficulty. When a single channel and the same speakers were used for both speech reinforcement and demonstration material, voice perspective and feedback problems interfered with each other. Using two sets of speakers—one for voice, the other for demonstration—was the solution.

One problem common to the AES and other groups is that most persons who address the gathering are technical people, not experienced public speakers. Such people can speak to small groups with ease, but they freeze up on a stage before a hundred listeners. The talker’s anxiety was often made worse by his poor microphone technique. Unaware that he should project his voice, he would often speak in a thin, weak voice, perhaps off mike. If the console gain was turned up, there was the possibility of feedback. When the lecturer turned away from the audience and gestured toward the screen to comment on a projected slide, he strayed farther off mike.

Several solutions to the microphone problem were attempted. A lavaliere

![Image 1](https://via.placeholder.com/150)

The hall as viewed from the console operator’s position. Two more speakers are used on right of stage to balance system.

![Image 2](https://via.placeholder.com/150)

Overhead mikes pick up talker’s voice even if he turns to side. Mike at lower right is used for questions from audience.

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mike was used, hung on a cord around the talker's neck. But transferring mikes between the first speaker, the program chairman, the next speaker and so on created another problem while it solved the first. Unmiking a lecturer was a nuisance, and he often stumbled on the mike cord. Next a wireless mike was tried. The sound was fine and there was no restricting mike cable, but occasionally a two-way radio harmonic would come popping through to disturb the audience's train of thought.

The best solution to the mike problem was found in 1963, when the lecturer was given complete freedom of movement. In addition to the usual lectern microphone, several long-range directional mikes were hung overhead, as shown in the photo. If the talker turned away from the lectern, his voice was picked up by these high-mounted mikes.

There were other developments during the past 10 years. An automatic-level-control amplifier was added to smooth out volume variations between various speakers on and off mike. Column speaker systems, because of their extremely directional patterns, could be placed very close to the lecturer without causing feedback. To most of the audience, the lecturer's amplified voice seemed to come from the person himself, enhancing realism. But when the lecturer walked across the stage to emphasize a point on a displayed slide, another problem was created. His voice seemed to stay at the lectern, and reality was lost.

An ingenious device called a pan pot solved the moving-talker problem. A variable attenuator, the pan pot channeled a monophonic signal into two separate speakers at stage left and right. The division of sound between the two was controlled by the position of the arm of the pot. With this device, when the lecturer crossed the stage, his voice could be "panned" between the left- and right-hand column speakers by the console operator. In other words, to the audience his amplified voice would stay with him as he moved.

With mikes hung overhead and lecturers walking around the stage, that old devil feedback would have crept slowly in, had it not been for the appearance of a device called a feedback stabilizer, or frequency shifter. Speech signals are fed into this stabilizer, which contains a circuit that shifts the whole frequency spectrum 3 to 5 hertz before sending it on to the loudspeakers. Since speaker acoustic output is not exactly the same as the sound waves from the talker's mouth, the two signals add only slightly at the microphone. The result is that, with the frequency shifter, speaker output in a PA system can be increased more before reaching the feedback point.

There were problems involving the audience, too. After a talk, the lecturer invites questions from those he's addressed. Their voices must be picked up for the permanent tape recording of the session. Hand-held or stand-mounted mikes were nuisances, as the questioner had to go to the mike, or the mike had to be passed to him. The answer was a battery of shotgun mikes aimed at vari-

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Simplified block diagram of the AES console. Dashed lines indicate components not a part of the console proper.
The console was designed for maximum operator convenience, to reduce possibility of error. Slide-type vertical attenuators conserve space on panel and are easy to use.

Ours sections of the audience. No one had to leave his seat, yet his voice could be captured for the record.

One thing learned through these years of experimentation applies to any PA system: The ideal setup should enhance the talker’s voice without becoming electronically obvious. In other words, it should be heard but not noticed by the audience—even if they happen to be audio engineers!

The AES console

Early in 1965, the design and fabrication of the present convention console was begun. All work was done by Society members who volunteered their free time. Equipment was donated by generous manufacturers. The console, which is entirely solid-state and uses PC-board modules for all circuits, is shown in the simplified block diagram.

There are 16 low-level microphone inputs, switchable into 8 preamplifiers. The first 3 preamps are followed by equalizers and booster amplifiers. After the loss introduced by the mike faders and the mixing bus, there follows a booster amplifier and a line amplifier. At this point, jack-field connections allow patching in an external limiting or level-controlling amplifier.

Next the signal is split three ways. The speech-reinforcement output goes through a master attenuator, an equalizer to compensate for hall acoustics and another line amplifier. If used, the frequency shifter is patched in at this point. Finally, the speech signal goes to the pan pot, and then to outboard power amplifiers and a pair of well matched column speakers.

A separate “special feed” output, with its own master and line amplifier, can be used for cueing or any other purpose. The third output from the speech-reinforcement section of the console goes through a separate master attenuator and line amplifier. It is then fed to a split-mixing network. More about this feature will be shown later.

The demonstration section of the console contains five high-level stereo inputs, switch-selected. They are normally driven by the line-level output of tape or disc recorders. These two-channel inputs are fed through balance pots and split networks, the latter to allow channel reversing or splitting a mono signal into both stereo channels. Next come the master attenuators, line amplifiers, and outboard power amplifiers and speakers.

The stereo demo inputs are also fed through separate attenuators into the split-mixing network mentioned previously. This network and the two line amplifiers which follow it constitute the recording section of the console. The network adds the lecturer’s voice to both stereo channels without degrading separation. Line-amplifier outputs are connected to a pair of outboard tape recorders which preserve everything heard at convention sessions.

To make it easier for the lecturer to hear questions from the audience, a separate facility is provided. All audience-reaction mike signals are pushbutton-selected into mike channel 8. The output of preamp 8 is tapped off through a separate attenuator, line amplifier and outboard power amplifier. Then it goes to a speaker mounted in the lectern. Thus the lecturer hears only audience questions, and not his own amplified voice.

Nearly every circuit path in the console appears on the patch panel beneath the operator’s armrest at the bottom of the slanting top panel shown in the photo. For even greater flexibility, a separate jack field in a standard 19-inch cabinet rack takes care of patching outboard amplifiers, limiters, etc.

All three VU meters may be switched, allowing visual monitoring of every channel and cueing of upcoming demonstration recordings. The meter at the left (top photo) normally rides the output of the voice-reinforcement channel, while the pair on the right are used to monitor the reference tapes being recorded.

The present AES system takes only about 8 hours to set up—including the time for positioning and hooking up lighting, slide projectors and a screen. That’s not bad, what you consider that the entire arrangement constitutes a highly sophisticated PA system, a complete recording studio, and facilities for reproducing tapes, discs, and (in some cases) sound-on-film movies. Twice a year the system is used 12 hours per day for 5 days.

My thanks to those members of the Audio Engineering Society who took the time to explain the intricate workings of this magnificent sound system for RADIO-ELECTRONICS readers.
NONPOLARIZED ZENER CLIPPER

A technique that eliminates the necessity of obtaining matched diodes in order to clip both sides of a waveform evenly

By RONALD L. IVES

CLIPPER AND VOLTAGE-REGULATOR CIRCUITS have been greatly simplified during the last 6 years. Biased diodes and overdriven triodes have been replaced by the simple and relatively inexpensive Zener diode. It has long life and requires no power supply, in most cases.

The conventional Zener clipper circuit is shown in Fig. 1. The positive half-cycle of the input waveform is clipped to Zener voltage $E_z$, the negative half-cycle is clipped to the $E_o$—offset voltage of the Zener diode, which is now acting as a conventional diode. This offset voltage, for most silicon diodes, either normal or Zener, is between 0.5 and 0.6.

The resistor is a current limiter, to minimize the dissipation of heat in the Zener. If the circuit of Fig. 1 is fed from a dc supply, it's a most effective voltage regulator.

Clipping of both half-cycles is customarily performed by using two identical Zeners connected back-to-back, as in Fig. 2. In this circuit, on each half-cycle one Zener functions as a voltage limiter, and the other as a conventional diode. Therefore, the peak of each clipped half cycle will be $E_a = E_z + E_o$, and $E_{out}$ will be $2 \times E_a = 2 \times E_z$ (peak-to-peak). The output will be very close to a square wave, provided $E_{in}$ is much greater than $E_{est}$.

The back-to-back circuit is an excellent performer, provided two identical Zeners are used. With high-power circuits, both diodes can share the same heat sink, which not only saves bulk and expense, but helps to keep the characteristics of both diodes in step.

A double-anode Zener will do just as good a job of clipping, but it's both costly and hard to get.

Recent development of small packaged bridge rectifiers, employing silicon diodes, has made it possible to obtain bilateral clipping with a single Zener, thereby eliminating the matching problem. Usually, the cost is reduced, too. Bridges such as the International Rectifier 10DB6 or Mallory FW series are ideally suited for this purpose.

The circuit of a Zener-bridge clipper is shown in Fig. 3. Due to bridge action, voltage is applied to the Zener diode on each half-cycle, and clipping takes place whenever applied voltage exceeds $E_a + 2E_o$.

Tests of this circuit show that it performs well in a variety of functions from oscilloscope calibration to crash limiting. Component life will be several years, unless the circuit is overloaded. The equipment they are used in is likely to become obsolete before the clipper components fail.
Perhaps you're a photographer and develop your own film. You need a device that will time your darkroom developing or enlarging an exact number of seconds. Then, too, you could be an industrial technician at a plant where raw material must be baked, mixed or otherwise processed for an exact number of seconds by automatic machinery. You want a device you can set to control the processing time.

What you need is an automatic timer, or electronic clock control. While you can purchase assembled timers and there are even a few kits, you'll learn more about electronic timing operations and troubleshooting if you build your own.

These two construction projects illustrate the principles of electronic timing. In both, the duty cycle and length of time interval may be varied. Either device will turn an external circuit on and off, or switch between two circuits. One is a vacuum-tube circuit which will repeat its switching action at intervals from less than 10 seconds to 90 seconds. The other circuit is solid-state and switches at intervals from 0.5 to about 17 seconds.

A vacuum-tube timer

The thyatron is a special type of gaseous tube used as an electronic switch. Two things are necessary to turn it "on" (start conduction)—both the grid and the plate must be positive with respect to the cathode. However, once it is turned on, there is only one way to turn the thyatron off—by breaking the flow of plate current. (This can be done by making the plate negative with respect to the cathode, or by simply disconnecting the plate or cathode from the rest of the circuit.)

The thyatron is ideally suited to be the heart of a timer. Fig. 1 is the circuit: Rectifier-filter circuit R2-D1-C2-R3 produces negative bias of ≈ 150 volts, which is tapped off by R3, the CALIBRATE control. This voltage is used as grid bias, as you'll see later. First assume that the recycling circuit, through contacts 1-2 of RY1, is open at point X. After power has been on for several seconds, the thyatron conducts on positive half-cycles at its plate. This energizes RY1, and its armature pulls down. Shunt capacitor C6 charges and holds the relay during negative half-cycles (when the thyatron isn't conducting). C3 is connected to the bias-voltage source through contacts 3-4 RY1; hence the capacitor charges to the voltage at the arm of R3.

If the cathode circuit of thyatron is now opened momentarily—by depressing the armature of RY2—the thyatron no longer conducts. RY1 is thereby de-energized, and its armature rises, placing the contacts in the "up" position. The negative voltage on C3 is now applied through contacts 4-5 to the thyatron grid, in parallel with resistor network R5 through R9. This negative bias prevents the thyatron from conducting.

This bias gradually leaks away through the resistive network, eventually bringing grid voltage to the tube firing point. When V conducts, it again energizes RY1. This switches C3 back to the "up" position, and applies ac voltage through contacts 1-2 of RY1 to recycling network D2-R11-R2C5. The open circuit at point X is closed.

With point X closed, operating pilot lamp PL3 lights and C5 charges slowly through D2 and R11. In about half a second the voltage across C5 is sufficient to actuate RY2, pulling down the armature. This opens the V cathode circuit, starting another time-limited nonconducting cycle. C4 counteracts the effects of any residual ionization in V.

Delayed recycling is needed so C3 can be fully recharged during conducting cycles of V. If the recycle charge is too short, timing will be erratic.

A panel control is provided for phasing the timing cycle, if necessary. This control (PRESS TO PHASE) discharges C3 and holds the V cathode circuit closed. When the control is released, a nonconducting cycle of thyatron operation starts immediately.

High-resistance network R5-R6-R7 is a grid equalizer. It offsets most of the effects of contact potential generated in the grid-to-cathode circuit of V.

The circuit to be controlled is connected to contacts 6-7 or 7-8 of RY1, which appear on terminals at the rear of the case. Note that, although there's no

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**Fig. 1—This vacuum-tube timing circuit uses a computer thyatron for reliable service.**
Neat labeling enhances front panel of the vacuum-tube timer. It's also a good idea to tag back-panel controls and switches.

The transformer isolating the plate of V1 from the ac line, the timer is not a hot chassis. There must not be an electrical connection from the line to the chassis, the case or the output terminals.

The timer is built in a utility box with a strong carrying handle and rubber feet. Neither panel nor interior layout is critical, with two exceptions. You must allow easy access to the relay contacts so you can keep them clean, and the CALIBRATE control must be reachable for adjustment. Also, it's a good idea to place the thyatron as far as possible from the timing capacitors. While a tube shield is used on V, it's merely serving as a holddown, to prevent the tube from coming loose in transit. A spring retainer would do just as well. R3 has a dial and a dial lock, taking much guesswork out of calibration adjustments.

The photos show suggested panel and interior layout. Note the use of tie points, which make troubleshooting and parts replacement easy.

Assembly is straightforward, and standard 10% components are used. The exception is R9, the value of which must be determined by the kind of pot you choose for R8 and the circuit you use.

In any good carbon pot, the ratio of resistance to rotation is substantially linear in the middle of the range. Close to each end, however, the ratio becomes nonlinear. By adding a resistor at the low-resistance end of R8, dial linearity can be extended to cover the range from 5% to 95% of rotation.

To determine the value of R9, connect an ohmmeter from the low end of R8 to the arm. Measure and record the resistance at each 10% of rotation point, up to 90%. Now, by subtraction, determine the successive differences in resistance between points. Those from 10% to 20%, 20% to 30%, 30% to 40%, etc. should be similar, and perhaps identical. From 0% to 10% will be a considerably lower value—the “end effect” mentioned previously. Find the average of the differences from 10% to 90%. From this average, subtract the measured value for the 0% to 10% position. The figure you obtain is the value of R9. You may have to juggle standard values, making up a hybrid of series and/or parallel resistors, to come up with the required value.

You can calibrate the timer easily with an ordinary electric clock that has a sweep second hand. Before you install the timer in the case, plug in the ac, turn on the power, and let the timer warm up for half an hour. Put a piece of paper between contacts 1-2 of RY1, so the timer won’t recycle automatically. Connect an electric clock in series with the ac line and the timer rear terminals, so the clock will run only when the RY1 armature is up.

Set the clock at zero seconds, the timer CALIBRATE control at approximately mid-range, and the SECONDS control (on the panel) at 50. Trigger the timer by depressing and releasing the armature of RY2. After the timer has gone through one cycle, note the elapsed time indicated by the clock. If the interval is more than 50 seconds, reduce the bias voltage by resetting the CALIBRATE control toward the low end. If the interval is less than 50 seconds, do the opposite. Make another trial run and continue adjustment until the clock-measured time is exactly 50 seconds, matching the sec-
of several million operations. Don't overload the contacts of RY1 with an external load. These contacts are rated at 5 amperes noninductive. If you use an inductive load, you must use a kickback-suppressing capacitor or the relay contacts will fail in short order.

The 5696 computer-type thyratron is often replaced after only 1,000 hours in highly critical applications. The one in the timer shown, however, is still performing satisfactorily after 8,700 hours.

The best rule is that the tube should be replaced when the timer calibration begins to drift badly.

The solid-state timer

This device uses a different approach to electronic timing. The heart of the circuit (Fig. 2) is an astable or free-running multivibrator. Two relay in the Q2 collector circuit is switched back and forth between two contacts by the oscillator. The repetition rate and duty cycle are governed by the settings of pots R1 and R2. Resistors R3 and R4, in the transistor base circuits, were found helpful in sharpening the switching action by linearizing currents from coupling capacitors C1 and C2.

This timer was built to light two lamps alternately and produce an audible "beep" each time it switched. The indicating circuit is shown in Fig. 3. The relay is switched by the timer of Fig. 2, firing first one lamp and then the other. Each time a lamp fires, a surge through C3 or C4 triggers blocking oscillator Q3 into a brief tone pulse. If either lamp burns out, the capacitor discharge path is opened and further beeps (on that half of the duty cycle) will be either weak or absent. Likewise, any change in the timer repetition rate or duty cycle will be similarly apparent.

If you eliminate C3 and C4 and use equal values for R5 and R7, the unit will produce a continuous tone that shifts in pitch, depending on which lamp is lighted. Another circuit variation is to replace the spot relay with a dpdt model. Then you can sample a pair of voltages or signals and still have visual and aural monitoring of switching action.

An ideal housing for this timer is a universal meter case, which can accommodate a 3- or 4-inch PM speaker in the meter cutout. The knockout holes in the case top can be used to mount adjusting pots R1 and R2, as shown in the photos. The perforated board used for mounting components is attached to the case back, the relay mounted inside.

The dials shown in the photo were calibrated in terms of shaft rotation, rather than on-off times. You might find it harder to compile a chart of time and duty cycles for any given pairs of

---

**Fig. 2**—Basic circuit shows operation of the solid-state timer.

**Fig. 3**—Indicator unit which can be used with timer of Fig. 2.

---

 Components

- C1, C2—100 µF, 25 volts
- C3, C4—see text
- C5, C6—0.22 µF, 100 volts
- D1, D2, D3—1N270
- Q1, Q2, Q3—2N2716 (G.E.)
- R1, R2—pot, 100K
- R3, R4—5.600 ohms, 1/2 watt
- T—output transformer, 500-ohm pri to 8-ohm sec (Lafayette TR 116 or equivalent); center tap not used

Miscellaneous—meter-case cabinet, Bud CMA or Premier ASPC; 5-terminal Jones strip; binding posts; circuit board.

---

**Underchassis view of thyratron unit shows suggested placement of most components.**
settings of R1 and R2. As an example, the following values of resistance vs.
repetition rate apply when R1 and R2 are equal and the duty-cycle is 1:1.

\[
\begin{array}{|c|c|}
\hline
R1, R2 & Time in ohms \quad in \ sec \\
\hline
8K & 0.5 \\
10K & 0.7 \\
15K & 1.7 \\
22K & 3.3 \\
33K & 6.0 \\
47K & 8.0 \\
68K & 12 \\
100K & 16-17 \\
\hline
\end{array}
\]

Fig. 4 is the schematic of the combined timer and audio indicator. D1
damps out induced transients in the relay coil. Diodes D2 and D3 isolate the two
circuits being activated by the relay.

It's often convenient to power the timer and indicator from the external
circuit which it controls. If 12 volts dc is easily obtainable, fine. The specified
2N2716 transistor has a \( V_{CEO} \) breakdown rating of 18 volts. For a higher-
voltage supply, you could substitute a 2N3404, which has similar hr, transfer
characteristics but a 50-volt \( V_{CEO} \) rating.

For portable use, a self-contained supply would be useful, and a pair of 6-volt
batteries, such as Burgess 2A, Eveready 724 or RCA VS068 will do nicely.

C3 and C4 aren't specified, since their value, as shown in Fig. 3, depends on
load impedances. Likewise, values of R6 and R7 depend on your particular
requirement. Their resistances determine the pitch of the indicator tone, so
you may want to use adjustable pots.

The model shown here was used in
the following hookup: The common re-
lay terminal was connected to a 12-volt
supply. The normally closed and nor-
mally open terminals of the relay were
closed to the signal lamps (Fig. 3).

Types 53 lamps, rated at 0.12 amp at 14
volts, were used. C3 and C4 were con-
nected between the relay terminals and
the audio-indicator input terminals. By
trial and error, it was found that 2 \( \mu \)F
produced a tone burst of about 0.1-sec
duration. R6 was made 38K, and R7 18K, to produce different tones for each
lamp. Later, for continuous tones, the
capacitors were omitted and R6 and R7
were increased to 47K and 68K.

This timer can easily be adapted for
darkroom use, as Fig. 5 illustrates. A
dpdt relay is used, and the lamps are
replaced with 470-ohm resistors.

To operate, open enlarger lamp
switch S before turning on the timer.
Adjust pots R1 and R2 so the closed
time is the desired printing interval, with
the open time about 5 seconds. With the
darkroom lights off and the timer beeping
away, wait for that moment when the
open-circuit tone comes on. When it
does, close the enlarger-lamp switch.
After a pause, the closed-circuit tone will
sound and the lamp will turn on. At the
end of the exposure time, the lamp will
go out with the return of the open-circuit
tone. Don't forget to open the en-
larger switch!

Fig. 4—Complete diagram of solid-state timer and indicator. C3 and C4 are optional.

Fig. 5—An example of the versatility of the timer—in the photographer's darkroom.
**BATTERY SELECTION GUIDE**

There’s a battery best suited to each application—depending on the current drain, hours of use, and above all the cost per cell.

With so much battery-powered equipment in use today, and with so many types of batteries available, choosing a battery for a particular application can be a real puzzle. The accompanying chart will help simplify the problem.

Batteries are rated in watt-hours per pound (in practical terms, milliampere-hours per ounce). The rating indicates battery efficiency. Zinc-carbon cells yield 15 to 20 watt-hours per pound, manganese-alkaline cells give 30, and mercury units produce 45. However, in any application, the current drain should not exceed the battery rating, or metallic ions will not be able to go into solution fast enough. This causes a rise in internal resistance, and the battery dies before it has yielded its normal quantity of energy. This action makes battery selection difficult. Available milliampere-hours for a particular current drain can be computed only for mercury and cadmium cells. For other types—zinc-carbon and manganese-alkaline—service life can be estimated in advance only from published data derived from actual performance figures.

Ordinary zinc-carbon dry cells require frequent “rest” periods. During use, the cells’ internal impedance increases due to the formation of hydrogen gas. This gas must be given a chance to dissipate or the useful life of the cells is shortened.

Zinc-carbon cells today are made in four types, depending on the intended service. The general-purpose variety is most common, and is usually called a flashlight battery. The second type is designed to operate under light drain and to maintain relatively constant terminal voltage for a longer period than can the first type. It’s used in transistor circuits. The third special kind of cell is made for photoflash use.
Manganese-alkaline cells can be up to 75% more efficient than zinc-carbon cells. This efficiency is chiefly useful in high-current applications, as they were designed for such use. Further, precautions must be taken in substituting them for ordinary cells. They cause corrosion when in contact with aluminum or copper terminals if there is any leakage of the caustic potassium hydroxide electrolyte. Stainless steel or nickel-plated steel terminals should be used. In spite of this disadvantage, manganese-alkaline cells are being used increasingly in receivers and amplifiers. Because they have a relatively constant internal impedance, they can be discharged to lower-than-usual voltages without causing distortion.

Even better in this respect are mercury cells. A 15M, for instance, can give about 220 hours of service at a drain of 10 mA before its impedance begins to rise (Fig. 2). Mercury cells are also better when stable operation is required. Their output voltage remains nearly constant throughout their useful life. Nor can their performance be surpassed when shock, vibration or moderate heat are problems. They are designed for use at room temperatures or above, and are excellent at low temperatures, as in hearing aids. (A special wound-anode type is available for use at low and freezing temperatures.)

A usual requirement of nickel-cadmium cells, because of their low voltage, is that the equipment be especially designed for their use. N-C's are economical only if you have facilities for recharging them.

On the other hand, when not discharged below 1.1 volts, they are able to take 200 to 300 recharges. Recharging can be done with a simple half-wave rectifier consisting of an inexpensive filament transformer, a diode and a 1-watt resistor. More elaborate circuits are sometimes used. Each size of N-C cell requires a different charging rate and therefore a different charging circuit. Recommended rates and circuits will be found in the various manufacturers' manuals.

These cells should not be used in emergency equipment since they have a poor storage life. At normal temperatures N-C's lose 12% of capacity in the first month, and they will be down to their cutoff voltage by the end of 2 months. They may of course be recharged to their normal capacity.

To select a battery from the chart, continued on page 66
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APPROVED FOR VETERANS ADMINISTRATION TRAINING

FEBRUARY 1967
BATTERY SELECTION GUIDE

continued from page 61

determine first the current requirement — let’s say 4 mA. Next, experimentally reduce the voltage of the circuit until an end-point, or cutoff, voltage is found — for instance, 1 volt — below which the circuit will not operate efficiently. Now establish the minimum practical length of service that will be required before battery replacement; assume 3 months. This would call for 130 hours of service from a unit used 2 hours per day 5 days per week. The nearest approximation on the chart is the 15F zinc-carbon AA cell drained at 5 mA and yielding 240 hours. No more economical service can be obtained from a 15A manganese-alkaline cell. It can be used for 290 hours, but the increased cost offsets the extra life.

Note, however, that the data given for manganese and mercury cells are for continuous usage. Thus, if the duty cycle is changed to more than 2 hours per day and the size limited to an AA cell, then only manganese and mercury cells will fill the bill.

On the other hand, suppose that the end point is 1.2 volts and the usage is 4 hours/day. By raising the end point, we have reduced the total amount of current that can be drawn from the cell. This reduces the number of hours of service. For a 4-hour/day usage, the 14F size-C cell is shown on the chart as delivering twice the current expectable from the 15F size AA at 2 hours/day. Probably, then, the 14F size C is the best bet for a 1.2-volt end point. But a recheck with the chart shows that the same length of service is also obtainable from a 15A AA-size manganese-alkaline. The final decision must rest on the duty cycle, for the 14F size-C zinc-carbon is economical only if the estimated 4 hours/day is never exceeded.

The chart also enables you to effectively substitute one style of battery for another. For instance, suppose a tape recorder with six 15F cells for the amplifier has a maximum drain of 7.5 mA. Would it be cheaper to substitute a type 1604 9-volt transistor battery? No, since 15F cells will give 110 hours of service at 10 mA, and the 1604 only 17 hours at such a drain. In other words, the 1604 gives only 15% of the service for 62% of the cost. Here, in fact, is a case where the ordinary zinc-carbon cell is more economical than any other type, including even the manganese cell.

In another recorder, type 13F D cells drain at 135 mA and need fairly frequent replacement. At the specified drain, heavy-duty zinc-carbon cells of the 13D type do not give better service than the ordinary 13F cells. Manganese cells might be the answer. As shown in the chart, the 13A gives 63 hours at a continuous 125 mA, as opposed to 36 hours at an intermittent 100 mA for the 13F cells. However, the recorder is not used for more than 4 hours at a stretch, and this is always followed by a 20-hour rest period. The question therefore arises, Wouldn’t industrial flashlight cells of the 13C type be much more economical than manganese?

It turns out that they would. This becomes clearer when we consider the two types in terms of their available mA hours (at the drains in the chart that are closest to the recorder’s drain of 135 mA). The 13C yields 5,800 mA-hr; the 13A, 7,875 (63 hr x 125 mA). There is apparently 74% as much power from the 13C for only 27% of the cost.

But unfortunately none of the manufacturers compared performance of the two types at the same drain with the result that the data on the manganese given in the chart are at a drain 25% higher than the 100-mA drain of the 13C. Therefore the 13A will yield more power at 100 mA. It computes out to about 8,700 mA-hr. Therefore, the 13A, when at 100 mA, yields about 50% more power than the 13C.

The cost of the cheaper battery times the percentage of better service of the more expensive battery equals the fair premium to pay for the extra service. Since the 13C costs about $0.16 the fair value of the 13A for this service is 0.16 / (0.50 x 0.16), which is $0.24. Obviously, with the 13A selling at $0.50, the 13C is the better buy for use under the particular conditions.

There is no simple answer to battery selection, as you can see. However, the chart will enable you to make good choices in most situations. Exact data on many drains, end points and duty cycles that are not given in the chart will be found in the Eveready, RCA and Burgess battery manuals.

Grateful acknowledgement is made to the Mallory Battery Company and Union Carvide Corporation for making special data available for use in this article.

END

References

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Circle 26 on reader's service card
The Lafayette HB-525 employs sophisticated design, unusual for a product retailing for only $149.95. It has a mechanical selectivity filter, noise limiter, squelch, frequency synthesizer, pi network, PA speaker jack, delta tuning switch and an illuminated channel-selector dial.

The HB-525 employs 19 transistors, 6 diodes, 1 thermistor and 12 factory-installed crystals. Circuit arrangements for receiving and transmitting are illustrated in Figs. 1 and 2. It is 6½ inches wide, 2½ inches high and 8½ inches deep, and weighs 4 pounds, 7 ounces. The unit is designed for direct operation from a 12-volt dc source and can be operated from ac through an optional power supply.

The pi network is used for both transmitting and receiving. But the receiver rf-amplifier tuned-input circuit has not been left out. There is an overload-protector diode to guard against strong signals at the front end. A series-resonant TVI trap is provided at the antenna end of the pi network.

The transmit frequencies and receiver-local-oscillator signals are generated in a frequency synthesizer system employing 11 crystals. One of the oscillators employs 6 crystals, another uses 4, and the third oscillator employs 1. The third oscillator is not used when receiving.

The signals from the first and second oscillators are fed into an up-converter which yields their sum frequency. This sum frequency is then fed into a down-converter together with an 11.275-MHz signal from the third oscillator to produce a beat at the channel frequency. For example: 23.24 MHz + 15.00 MHz = 11.275 MHz = 26.965 MHz (channel 1). Each of the converter stages employs a three-section bandpass filter to attenuate unwanted frequencies.

The output of the down-converter is fed to the rf power amplifier through a buffer stage and a driver stage. The collectors of both the driver and rf power-amplifier stages are amplitude-modulated by a push-pull class-B modulator.

The output of the up-converter, at a frequency equal to the sum of the first and second oscillator frequencies, is fed to the first receiver mixer. This stage yields an 11.275-MHz i.f. signal, which is passed through an LC filter. The signal then goes to the second mixer, where the 11.275-MHz i.f. signal is heterodyned against an 11.73-MHz signal from the delta-tune oscillator, producing a 455-kHz second-i.f. signal. By means of a front-panel switch, the frequency of this oscillator can be shifted above or below 11.73-MHz to permit clear reception of off-frequency signals.

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Knight-Kit KG-895 All-Transistor Stereo

Circle 29 on reader's service card

IN EXAMINING THIS HIGH-POWER amplifier one is impressed by its size and weight. Ultramiinaturization in solid-state hi-fi equipment is a thing of the past, and rightly so. Knight saw field trouble would be caused by compressing 120 watts of music power into a compact chassis. Instead, their engineers spread out components in a carefully planned chassis. It contains adequate heat sinks for the eight conservatively operated power-output transistors. There are four per channel in a low-voltage, high-current bootstrap arrangement. There is a large, cool-running power transformer equipped with a hum-reducing copper strap.

Conveniently grouped on a fully shielded and enclosed input panel are the phono, tuner, tape and tape-head inputs, the last equalized for NAB standards. There are also two auxiliary inputs per channel.

Outputs for tape recording are provided at low impedance, together with facilities for tape recorders equipped with a separate monitoring head. While a means is provided for operating two sets of stereo speaker systems, front-panel switching does not permit operation of both pairs simultaneously. This is a wise precaution, since even the best audiophiles often fail to heed impedance warnings in instruction booklets. Although speakers as low as 4 ohms may be used with the KG-895 with absolute safety, two such 4-ohm speakers must not be paralleled on one output. This would reduce the effective impedance seen by the output transistors to 2 ohms—a condition which is hardly fair to output transistors. However, even this misuse would not cause permanent damage to the output transistors; they are fully protected by vacuum-sealed circuit breakers which pop open if output current is excessive. In fact, we deliberately shorted the output of one channel. (This must be done deliberately; the speaker terminals are on a barrier strip.) When we drove the amplifier to 60% rated output power, the circuit breakers did their job instantly. The output transistors were in no way damaged after this experiment, and performed...
just as well as their opposite-channel counterparts. The brushed-gold aluminum front panel is attractive, but more important, it contains control knobs and switches you don’t find in so-called “simplified” arrangements. There are the usual balance, level, bass and treble controls. (The tone controls are the clutch type, permitting independent compensation for each channel.) A switch is provided which offers four values of loudness compensation. The functions of high- and low-frequency filters (6 db per octave above 3,000 Hz and below 50 Hz, respectively), normal-reverse, tape monitor, speaker selection and power on-off are all actuated by logically placed, positively operating rocker switches. The program-selector switch is not surrounded by a paragraph of nomenclature. Instead, the signal source in use is indicated by soft illumination of one of six colored rectangular light panels located in the center of the front panel.

Interestingly, the program-selector switch has no stops at each end of rotation, thus, to switch from AUX 1 to TAPE it is not necessary to go all the way through TAPE HEAD, PHONO, TUNER, etc. A minor feature, perhaps, but indicative of a sincere attempt to provide convenience and ease of operation for the user. The usual stereo headphone jack and a stereo-mono rocker switch are also on the front panel.

It was with trepidation that we put the KG-895 through listening and measurement tests. Happily, our ears and test instruments confirmed what our eyes had suspected. The manufacturer’s specifications are listed separately, but here are some we measured without regard to published specs.

<table>
<thead>
<tr>
<th>Distortion at 1,000 Hz (one channel only)</th>
<th>Power Output (rms watts)</th>
<th>Harmonic Distortion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.3</td>
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<tr>
<td></td>
<td>10</td>
<td>0.4</td>
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<td></td>
<td>20</td>
<td>0.55</td>
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<tr>
<td></td>
<td>40</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note that our 40-watt measurements actually turned out a bit better than the manufacturer’s claim (0.7%). Frequency response (with tone controls adjusted for electrically flat response) at normal listening level was, as expected, better than that listed for full power output, measuring flat within 1 dB from 15 to 38,000 Hz. Power bandwidth (not supplied by manufacturer) was 30 to 18,000 Hz (3 dB, 0.7% distortion points) at 40 watts rms per channel.

As for the circuitry itself, each channel has a separate, three-transistor plug-in preamplifier module. All signals (both high and low level) are fed through proper equalizing and attenuating networks to this module. The preamp is followed by a separate emitter-follower stage which provides the low impedance necessary for tape output. The tone control and loudness stages, along with the various intermediate filters and rocker-switch circuits are next.

Two transistor amplifier stages per channel compensate for tone-control attenuation. The balance and level controls are located after these stages for best signal-to-noise ratio and lowest hum level. The power-amplifier portion of each channel consists of two voltage-amplifying stages, the driver stage and a driver transformer (notably free of any direct current in its primary winding) which drives the double-push-pull class-B output transistors.

The speakers are connected to the output transistors at zero volts dc, since the four output transistors operate over a voltage gradient from +35 to −35 dc. Each transistor has a maximum of only 17.5 volts across it from emitter to collector—a highly conservative mode of operation for these large IQ-3 types. The only specifications with which we might find fault (and small fault, at that) would be the damping factor and the hum level. A damping factor of 6 seems a bit low for this type of equipment. The hum level did, indeed, measure 70 db below full power output, as stated by the manufacturer. Residual hum (with volume control turned fully counterclockwise) was not much better, however, measuring only 75 db below full output.

By the way, the manufacturer supplied me with a wired model of the KG-895, and I therefore cannot comment on how easily this kit can be constructed.

Summarizing, an honestly designed high-power stereo amplifier has to be big, transistorization notwithstanding. The KG-895 is both big and honest.

Leonard Feldman

MANUFACTURER’S SPECIFICATIONS

Power output (8 ohms): 60 watts IHF music power, 40 watts continuous sine-wave power, per channel

Frequency response: ±1 db 18 Hz to 30 kHz at full rated power

Harmonic distortion: 0.7% at rated power output

Intermodulation distortion: less than 1% at rated power output, 60 Hz and 7 kHz mixed 4:1

Hum and noise: 70 db below rated power, tuner on

Separation: better than 55 db

Damping factor: 6 when used with 8-ohm speakers

Size: 16" x 15 x 5½ in.

Price: $149.95 as kit only

ABC’s of Varactors by Rufus P. Turner. A basic introduction to varactors—a special group of semiconductors whose capacities varies with the voltage applied. Explains operating principles and describes typical circuits in which they are used. Describes use in microwave applications, for which they are particularly suitable, as well as uses in receivers, transmitters, and amplifiers. An easily understandable book for anyone who desires to be informed on this comparative newcomer in the semiconductor field. 96 pages; 5½ x 8½.

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PACE 5803 Laboratory Power Supply

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A POWER SUPPLY THAT WILL FURNISH regulated low-voltage dc is an essential part of almost any laboratory in these transistor days. Although less sophisticated versions can be used for servicing, a supply like the Pace 5803 gives a technician confidence that his equipment is doing the job properly.

To fill the need in the lab (and elsewhere) Pace has developed a supply using two regulator amplifiers in cascade and a separate voltage-reference source. The output is continuously variable from zero to 15 volts with a maximum continuous capability of 2.5 amps. The supply will withstand a short-duration output overload, and is protected by a circuit breaker for long overloads. Short-circuit current is about 6–7 amps. Two edge-reeding meters (see photo) continuously indicate output voltage and current.

The 5803 uses one npn and two npp transistors in a de-coupled amplifier circuit and two Zener diodes for regulation and electronic filtering. A center-tapped power transformer and silicon rectifiers D1 and D2 form a full-wave power supply; its negative output is connected to the emitter of Q1. The Q1 collector is connected to the negative output terminal, which is the common ground. With this arrangement Q1 is in series with the negative output lead and...
its effective resistance determines the output voltage. The resistance of Q1 is changed by varying the base bias voltage. A more positive voltage will cause the transistor to conduct more and thus look like a smaller resistor (to the power supply). A more negative bias will make Q1 conduct less and look like a larger resistor.

To make Q1 more sensitive to slight changes in output voltage, two additional amplifiers—Q2 and Q3 are used. Also, to provide a reference-voltage source apart from the main dc supply, two diodes (D3 and D4) are added across the secondary of the power transformer. These diodes furnish a positive voltage output, which is fed through the lamp and then to a 10-volt Zener diode. The Zener diode furnishes a stable 10-volt reference source through the on-off switch to the base-bias circuit of Q3. This source is also applied to the emitter of Q3 through R2, where the voltage is further stabilized by Zener diode D4. The base of Q3 monitors the output voltage developed across R6, R7, R8 and D5 in series.

To get an idea of how the regulator circuit works, let's assume that a variation in load current has caused a variation in output voltage. This change in the output voltage of Q3 shifts its base-to-emitter voltage and produces a corresponding change in collector current. This changing collector current causes a change in the base currents of Q1 and Q2, which are connected in cascade. The collector current of Q1 then increases or decreases as required to restore the output voltage to its preset level. In all power supplies using series regulation the power-output capability is roughly proportional to the square of the output voltage. According to the graph supplied with this unit, power output should not exceed about 6 watts at 6 volts but can be as much as 24 watts if the voltage is increased to 12. Why? As output voltage increases, the voltage drop across the transistor decreases. As an example, if the output current is 2 amps at 12 volts, the drop across Q1 is 3 volts. Since power is equal to E x I, Q1 must dissipate 6 watts. If the output is dropped to 6 volts, the drop across Q1 is 9 volts (assuming a nominal 15-volt supply output). With 2 amps output current, Q1 must now dissipate 18 watts, exceeding its rating and shortening its life.

I used this supply to power several transistor receivers (including a large car radio) and could hear no hum in the speaker even near maximum current output. In addition, as far as I could determine, there was no tendency toward instability or motorboating at any load current.

One thing I appreciated about the 5803 was the lack of "cushion" delay. When the voltage is changed, the lightly damped meter follows this change immediately with virtually no overshoot.

The on-off switch operates a "kill" circuit which drops output voltage zero quickly when the supply is turned off. It does this by placing a 100-ohm resistor across the 5,000-µF filter capacitor and blocking the regulator amplifiers.

I can recommend this supply as doing a fine job within its capabilities. The output terminals will take bare wire, pin or banana plugs, as well as the dual banana plugs commonly used by laboratories. The small size of the 5803 makes it easy to fit almost any bench.

The specifications given by the manufacturer are accurate and even conservative.—Wayne Lemons

**MANUFACTURER'S SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Input voltage for full regulation: 105-130 Vac, 60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output voltage: adjustable 0-15 Vdc</td>
</tr>
<tr>
<td>Output current: 2.5 amps maximum</td>
</tr>
<tr>
<td>Regulation (worst case): 1.5%</td>
</tr>
<tr>
<td>Regulation (no load to full load, with constant line): 1.0% or less</td>
</tr>
<tr>
<td>Ripple (worst case): 3 mV</td>
</tr>
<tr>
<td>Ripple (continuous): 1 mV</td>
</tr>
<tr>
<td>Price: $59.95</td>
</tr>
</tbody>
</table>

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The Trouble That Couldn’t Happen

By MILTON LOWENS

Part II—The Cure

IN A CIRCUIT AS SIMPLE AS THIS ONE, THERE WERE VERY FEW things that could cause complete inversion of the picture. Since voltages were essentially normal, vertical oscillator trouble could be ruled out. The negative voltage on the grid was a clear indication that the stage was functioning, while the stable picture indicated that the oscillator frequency was correct. This left only the vertical output stage which, besides the tube, consisted of resistors in the grid and cathode circuits and the vertical output transformer. Since resistive components cannot possibly cause a phase inversion, that left only the transformer. This reasoning was proved correct as soon as a new transformer was installed, but what could cause the old transformer, a simple unit, to act as it did? I was determined to find out.

I studied the complete schematic diagram and redrew the portion dealing with the vertical output stage in simplified form (Fig. 1). The direction of electron flow naturally was from the plate down through the windings to B+. At the bottom terminal of the transformer (black lead) there should have been negative-going spikes which, when applied to the grid of the picture tube, would blank out the retrace lines. However, since removing the spikes had an effect precisely opposite to what would be expected, this clearly indicated, even without a scope, that the spikes were actually positive-going. When this peculiar indication was coupled with the inverted picture, only one conclusion was possible: the direction of electron flow through the windings must have been reversed! Frankly, I did not see how this could be, since electrons cannot flow from plate to cathode, at least according to the very theories I taught my students. Still, I ordered a new transformer anyway when I discovered that the resistance readings of the windings were incorrect and erratic. While I waited for the new transformer, I performed an autopsy on the suspected unit. Too many competent people had called this “the trouble that couldn’t happen” for me to stop now.

I removed the mounting frame and core first. Then, slowly and very carefully, I peeled off the outer layers of insulating cloth and paper from the windings. There it was! A tiny black charred spot under the fine enameled wire where it crossed on top of the winding to be soldered to the blue outgoing lead (Fig. 2). Directly under this fine wire, separated from it by a thin layer of transparent plastic film, lay the top layer of the winding which terminated in the black outgoing

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**Fig. 1—Simplified vertical output stage in mysterious TV.**
lead. Thus the full sharply-spiked voltage appearing between the ends of the entire winding was opposed by only a few thousandths of an inch of insulation intended to resist only the relatively low voltage between adjacent winding layers. No wonder it had broken down! Only a quarter inch away lay a much heavier piece of varnished cambric which could have stopped the breakdown, but either the wire or the cambric were not where they should have been. And this was enough to cause the whole problem.

As shown in Fig. 3, the breakdown effectively caused a short-circuit of the entire winding. The heat generated welded the black-connected lead to the blue-connected lead. At the same time, the end of the winding ordinarily connected to the blue plate lead burned open. Thus, the effect was exactly as if the transformer had been reversed; this inverted both the picture and the polarity of the blanking spikes. The picture was of less than normal height because there were fewer turns in the winding between the black and green leads than in the normal coil between the red and blue.

So, at last the problem was solved.

"Hey!" you may call. "Not so fast! What about the backwards picture? What caused that?"

Well, that one puzzled me a long time too. The set was fixed, the customer was happy and so was I; I had cracked a tough nut and had been well paid. Ordinarily I would have been satisfied to let it go at that except for one thing. I remembered the Magnavox technician pleading earnestly, "If you ever do find out what caused the trouble, would you let me know?"

So to finish it: Did you ever see a vertical foldover at the
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**TECHNOTES**

**PHILCO 8H25: INSUFFICIENT HEIGHT**

Since width was normal, I checked and substituted the 10DE7 vertical oscillator to get full height. No dice— the tube was good. The 10DE7 plate had only 10 volts; normally, it should have had about 125. A check of the schematic indicated that both the boost and B+ voltages were fed to a common tie point, where an electrolytic went to ground (see drawing). This point was the source for the 10DE7 plate.

![Diagram of Philco 8H25 circuit](image)

Voltage at the electrolytic was only about 140, whereas it should have been 425. With a capacitor checker I found the capacitance normal, but the power factor was greater than 50%—indicating bad leakage. I replaced the 10-μF, the screen filled out, and height was okay.—Domenic Ripani

**CLEVELAND LATHE SPEED-CHANGE PROBLEM**

An earlier Technote stated that failure of a Cleveland Dialmatic lathe to change from rapid-advance to feed speeds was sometimes caused by a defective cam-operated switch on the programmer.

Additional experience has shown that the same trouble may be caused by the two-coil latching relay operated by the cam switches.

This relay will check good on an ohmmeter and will operate at reduced speed but will not change over at normal machine speeds.

Replacement is necessary.—R. C. Roetger
NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

MONOLITHIC DUAL TRANSISTORS

The 2N4099 and 2N4100 are two of a series of dual npn silicon planar transistors made by Union Carbide. The two matched sections of each dual transistor are isolated by dielectric lay-

ers. The transistors feature very high dc gain, low noise, close parameter match and good thermal tracking.

Maximum ratings

2N4099 2N4100

Diss. at 25°C
Each side 0.3W 0.4W
Both sides 0.5W 0.75W

VCEO 55 55
VCEO 55 55
VCEO 7 7
Ic 10 mA 10 mA
Ic 200°C 200°C

Matching characteristics

Max.

β (hFE/βRE) 1.0

Vβ = Vβ β 5mV

Iβ - Iβ β 10nA

Δ (Vβ - Vβ β) 5.0μV/°C

Δ (Iβ - Iβ β) 0.5nA/°C

The 2N4099 is in a TO-70 (6-lead TO-47) case. The 2N4100 is in a TO-78 (low-profile 6-lead TO-5) case. The base diagrams are shown.

CONTACTLESS SWITCH

The Photocom, a solid-state spst switch for low-level switching, consists of a neon lamp that drives a photoresistive cell. Ideal for use as a shunt or series modulator or chopper in operational amplifiers in pH meters, electrometers, servo controls and other applications where low-noise low-level switching is needed. A typical dc and dc pulse drive circuit is shown. These units, made by James Electronics, are available as 10 types in two miniature resistorlike packages 3/8 in. diameter and 1/4 in. long. The “A” package has five goldplated wire leads for easy PC mounting. The “B” package has 6-inch shielded output leads. Pertinent specifications for the C-4821 and C-4840 in the “A” package and the C-4825 and C-4841 in the “B” package are:

| Drive volts | 120 | 120 |
| Switching pwr (max mW) | 50 | 50 |
| On resistance (ohms) | 5K-50K | 10⁹ |
| Off resistance (ohms) | 10² | 10¹¹ |
| Turn-on time (msec) | 0.75 | 0.75 |
| Turn-off time (msec) | 3 | 3 |
| Insulation res (megs) | 10,000 | 100,000 |

2N3950-50 WATTS AT 50 MHZ

This new transistor delivers at least 50 watts continuous power output at 50

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This multiple-emitter transistor is in a grounded-emitter TO-60 package. Its data sheet, available from Technical Information Center, Motorola Semiconductor Products, Inc., Box 955, Phoenix, Ariz. 85001, includes such important design parameters as parallel equivalent input resistance and parallel equivalent input and output capacitance. The availability of these specifications simplifies the design of large-signal rf output stages, avoiding the usual trial-and-error methods.

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You can also tell if the line should be shorter or longer by rolling some of it. If the interference gets worse with rolled-up line, the line definitely does not need to be longer.—Tom Jaski

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The bottom of the can is weighted for stability by pouring in some melted lead or by attaching a piece of soft iron. The rest of the can is then packed with medium steel wool for cleaning the hot tip. Steel wool is much better for this than a dirty rag.

An alligator clip on a short length of No. 18 wire is bent, and the body of the can to act as a "third hand" in holding small parts for soldering or holding a bit of solder. A strong rubber band around the can holds small tools, emery paper, hook-up wire or a bank of solder. A coat of enamel hides the caddy's humble origin.—William H. Grace, Jr.

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Willis C. Ware, Jr.

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PROJECTION TELEVISION COMPONENTS WANTED. Need optics systems and projection tubes. State price and condition. J. KRIZSAN, 2519 Ashurst, Cleveland, Ohio 44118

WANTED: Name of manufacturer of Mark II Antibug Electronic Device. WILKIE-MOORE APPLIANCE CO., 118 S. Main, Waggoner, Oklahoma 74467

FARNSWORTH 10" table television GV-240, GV-250, GV-260, C. T. BROWN, 1004 Burr, Corona, Calif. 91720

AUDIO — HI-FI

RENT STEREO TAPES—over 2,500 different—which major labels — free brochure. STEREO PARTI, 1616 R Terrace Way, Santa Rosa, Calif. 95404

Hi-FI COMPONENTS, Tape Recorders, at guaranteed "WE will not be undersold!" prices. 15-day money-back guarantee. Two-year warranty. NO Catalog Quotations Free. HI-FIDELITY CENTER, 2398 East 149th St., N. Y. 10545

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**Electronics**

BARGAINS in Canadian Electronic equipment and Surplus Steal $1.00 for giant catalogs. ETCO, Dept. R, 820 Fifth Avenue, New York, N.Y.

**PROFESSIONAL ELECTRONICS PROJECTS—$1 up. Catalog 25c. PARKS, Box 2566A, Seattle, Wash. 98121**

**TUBES. “Oldest,” latest. Lists Free. STEINMETZ, 7519 Maplewood, Hammond, Indiana 46324**

**JAPAN & HONG KONG Electronics Directory. Products, components, supplies, 50 firms—just $1.00. I.PPANO KAISHA LTD., Box 6626, Spokane, Washington 99207**

**SURPLUS SEMICONDUCTORS and miniature electronic parts. Send 25c for catalog, ECD COMPANY, P.O. Box 1432, Plainfield, N. J. 07080**

**TV CAMERAS FOR EXPERIMENTERS and industry. Expand line includes monitors, vidicons, lenses, tripods, cases, etc. New 1967 catalog, TV & NUCLEAR RESEARCH, Box 3566-R, St. Louis City, Neb. 68176**

**FREE Catalog. Electronic parts, tubes, Wholesale, money-saving specials. Unbeatable prices. ARCTURUS ELECTRONICS RE, 502-22 St., Union City, N. J. 07087**

**TV CAMERAS, converters, etc. Lowest factory prices. Catalog 12c. VANGUARD, 125-25 Jamaica Ave., Hollis, N.Y. 11423**


**Business Aids**

JUST STARTING IN TV SERVICE? Write for FREE 36 PAGE CATALOG of Service Order books, invoices, job tickets, phone message books, statements and file systems. GELRICH RADIO CORP., 132 (RE) Nassau St., New York, N.Y. 10038

1,000 Business Cards. "Raisied Letters" $3.95 postpaid. Samples. ROUTH, 5717 Friendswood, Greensboro, N. C. 27409

DIAGRAMS, servicing information, Radio $1.00, Television $1.50. BEITMAN, 1760 Balsam, High- land Park, Illinois 60035

**Business Opportunities**

TRAIN for solid high paying career in electrical repair. Experimental kits included. Free facts pack. I.T.I., Dept. 65033, 815 E. Rosedale, Los Angeles, Calif. 90059

INVENTIONS—IDEAS developed. Cash/Royalty sales. McGRAW-HILL COMMERCE, Raymond Lee, 130-U W. 42nd, New York City 10036

INVENTIONS NEEDED! Free analysis. Depend- able service. Experiened personnel. MILL STREET PROMOTIONS, INC., 99 Wall Street, New York, New York 10005

A large midwestern university is seeking an ELECTRONICS TECHNICIAN. Must be able to perform routine maintenance and repair of electronic equipment. Must have familiarity with both electron tube and solid state circuitry, and must be able to design, construct, and modify electronic equipment. Apply Personal Office, UNIVERSITY OF ILLINOIS AT CHICAGO, 5100 Rockhill Road, Kansas City, Missouri.
### Classified Advertising Order Form

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### Classified Commercial Rate

- Commercial Rate for (firms or individuals offering commercial products or services): 60¢ per word...minimum 10 words.
- Non-commercial Rate for (individuals who want to buy or sell personal items): 90¢ per word...no minimum.

Payment must accompany all ads except those placed by accredited advertising agencies, 10% discount on 12 consecutive insertions, if paid in advance. Mislabeled or objectionable ads not accepted. Copy for March issue must reach us before January 9th.

WORD COUNT: Include name and address, Home of city (Des Moines) or state (New York) counts as one word each. Zone or Zip Code numbers not counted. (We reserve the right to omit Zip Code if space does not permit.) Count each abbreviation, initial, single figure or group of figures or letters as a word. Symbols or groups such as 8-10, C.D., AC, etc., count as one word. Hyphenated words count as two words. Minor overworkage will be edited to match advance payment.
INTERNATIONAL FREQUENCY METERS

designed for servicing!

Equip your lab or service bench with the finest

FM-5000 FREQUENCY METER
25 MC to 470 MC

The FM-5000 is a beat frequency measuring device incorporating a transistor counter circuit, low RF output for receiver checking, transmitter keying circuit, audio oscillator, self contained batteries, plug-in oscillators with heating circuits covering frequencies from 100 kc to 60 mc. Stability: ± 0.0025% +85° to +95°F, ± 0.0055% +50° to +100°F, ± 0.001% +32° to +120°F. A separate oscillator (FO-2410) housing 24 crystals and a heater circuit is available. Shipping weight: 18 lbs.

FM-5000 with batteries, accessories, less oscillators and crystals.
Cat. No. 620-103 ........... $375.00
Plug-in oscillators with crystals $20.00 to $50.00

Model 7212 FREQUENCY METER

The International Model 7212 portable second order frequency standard is a self contained unit designed for servicing radio transmitters and receivers used in the 400 kc to 500 kc range (can be modified for other frequencies on special order). Frequency accuracy is ± 0.01% from 32°F to 104°F (0°C to 40°C). The meter holds eight crystals. Features include the transistorized frequency oscillator and built-in battery charger. Shipping weight: 18 lbs.

Model 7212 complete with crystals.
Cat. No. 620-103 ........... $575.00

C-12M FREQUENCY METER
For Marine Band Servicing

The C-12M is a portable secondary standard for servicing radio transmitters and receivers in the 2 mc to 15 mc range. The meter has sockets for 24 crystals. Frequency stability is ± 0.0025% 32° to 125°F, ± 0.0015% 50° to 100°F. The C-12M has a built-in transistorized frequency counter circuit, AM percentage modulation checker and modulation carrier and relative percentage field strength. Shipping wt. 9 lbs. C-12M with PK (pick-off) box and connecting cable, batteries, but less crystals.
Cat. No. 620-104 ........... $235.00
Crystals for C-12M (specify frequency) $7.00 to $10.00

CRYSTAL CONTROLLED C-12 ALIGNMENT OSCILLATOR

The International C-12 alignment oscillator provides a standard for alignment of IF and RF circuits 200 kc to 60 mc. It makes the 12 most used frequencies instantly available through 12 crystal positions 200 kc to 15,000 kc. Special oscillators are available for use at the higher frequencies to 60 mc. Maximum output 4 volt. Power requirements: 115 vac. Shipping wt. 9 lbs. C-12 complete, but less crystals.
Cat. No. 620-108 ........... $65.50

Write today for our FREE CATALOG

Circle 148 on reader's service card

C-12B FREQUENCY METER
For Citizens Band Servicing

This extremely portable secondary frequency standard is a self contained unit for servicing radio transmitters and receivers used in the 27 mc Citizens Band. The meter is capable of holding 24 crystals and comes with 23 crystals installed. The 23 crystals cover Channel 1 through 23. The frequency stability of the C-12B is ± 0.0025% 32° to 125°F, ± 0.0015% 50° to 100°F. Other features include a transistorized frequency counter circuit, AM percentage modulation checker and power output meter. Shipping weight: 9 lbs. C-12B with PK (pick-off) box, dummy load, connecting cable, crystals, batteries.
Cat. No. 620-101 ........... $500.00

KEEPING YOU ON FREQUENCY IS OUR BUSINESS . . .

INTERNATIONAL
CRYSTAL MFG. CO., INC.
19 NO. LEE - OKLA. CITY, OKLA. 73102

Model 1110 SECONDARY FREQUENCY STANDARD

The Model 1110 is an economy portable secondary standard for field or bench use with self contained battery. Using any general coverage communications receiver the unit provides the necessary standard signal for measuring frequencies. Easily calibrated against WWV to provide an accuracy of ±.1x10°. Long term stability of ±10 cycles over range 40°F to 100°F. All transistor circuits provide outputs at 1 mc, 100 kc and 10 kc. Zero adjustment for oscillator on front panel. SHIPPING WEIGHT—12 lbs.

Model 1110 complete.
Cat. No. 620-106 ........... $125.00

RADIO-ELECTRONICS
Another great new sales booster from Cornell-Dubilier!

This new and completely revised 16-page booklet is a hard working sales tool. It explains to your customers—in non-technical language—how and why their TV and FM reception can be improved with a CDE Antenna Rotor System.

The booklet is designed to help you convince buyers of new color TV sets—as well as the present owners of FM and Black-and-White sets—that they should consider a high quality CDE Rotor System.

Make sure you have enough copies on hand. They're available free of charge. Ask for your supply today.

Circle 149 on reader's service card!
No color?

Use this procedure to narrow down the trouble area...

If the receiver produces a normal black and white picture but no color during a color broadcast, try the following steps, in order:

1. Tune to a channel broadcasting color, or feed an rf color-bar signal into the antenna terminals.
2. See that the fine-tuning and color (saturation) controls are correctly set.
3. Rotate the color-killer threshold adjustment in the direction which disables the color-killer stage. If locked-in (in sync) color appears, reset this control as recommended by the set manufacturer.
4. If color appears out of sync, look for trouble in the automatic frequency and phase control (AFPC) circuits. Use a color-bar generator, and follow the AFPC adjustment procedures described in the manufacturer’s service notes.
5. If no color appears, determine whether the color is lost in the circuits which handle the composite signal (antenna to bandpass amplifier) or in circuits that handle the separated color signal, as follows:
6. Feed a color-bar signal into the antenna terminals and use a scope to check the composite signal at the video detector.
7. If color-bar waveforms are absent or badly distorted, check for trouble, including poor bandpass between the antenna terminals and video detector.
8. If color-bar signals are present at the video detector, check the burst keyer or separator, bandpass amplifier, color killer, and the 3.58 MHz oscillator stages and their associated circuits.
9. Once the inoperative stage is found, use voltage and resistance measurements to pinpoint the circuit defect.

This ad is still another in a series of color TV service hints from RCA. To keep your customers satisfied, always replace with RCA receiving tubes. Your local RCA Distributor is your best source for top quality receiving tubes for color TV.

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N.J.