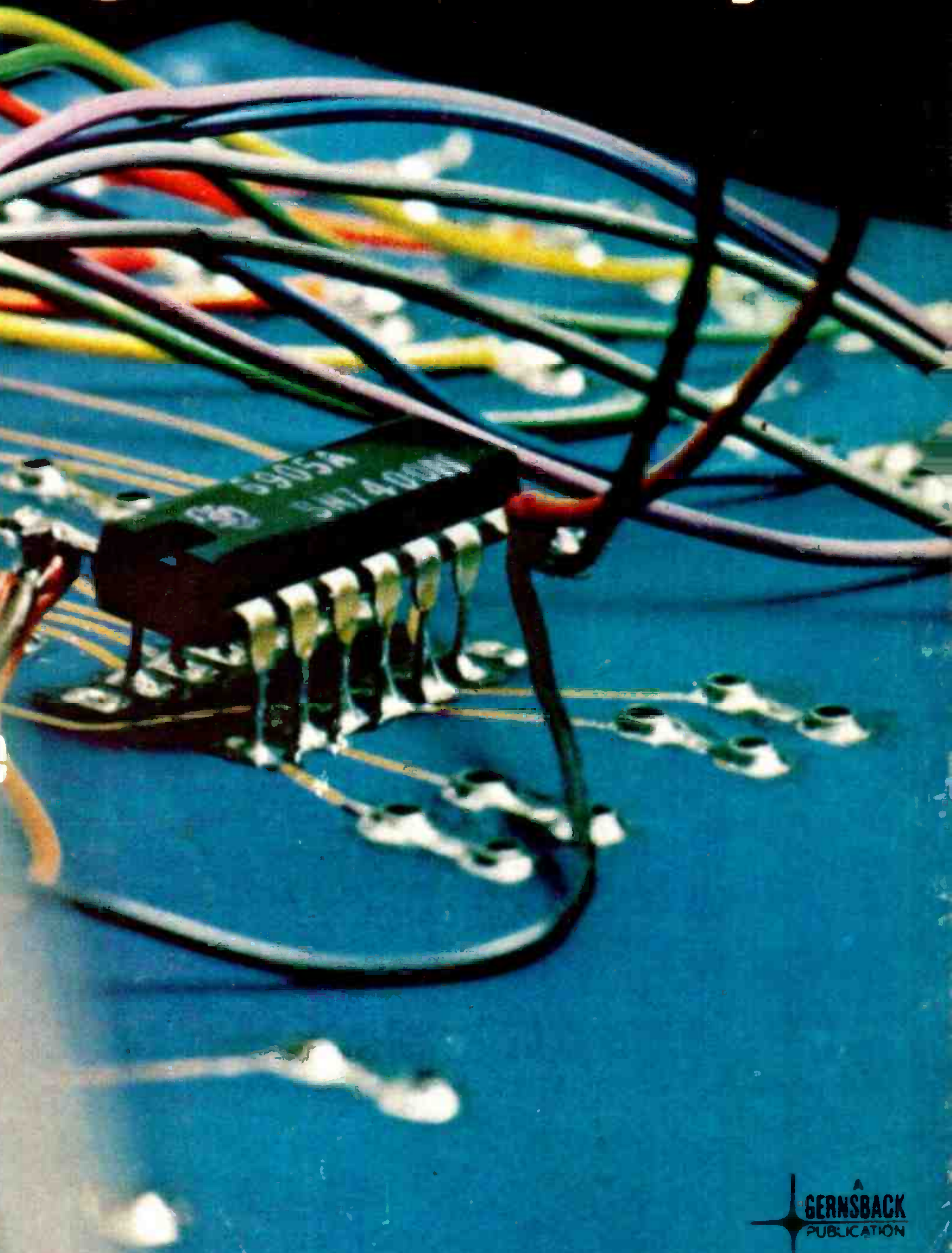
60c ■ DEC. 1970

Radio-Electronics

IND

FOR MEN WITH IDEAS IN ELECTRONICS

BREADBOARD A COMPUTER WITH
R-E's Logic Laboratory



STARTING THIS ISSUE
Designing Hi-fi amplifiers

THE TROUBLESHOOTER
Case of the Siamese Pentode

4-CHANNEL STEREO
Two New Approaches

A GERNSBACK PUBLICATION

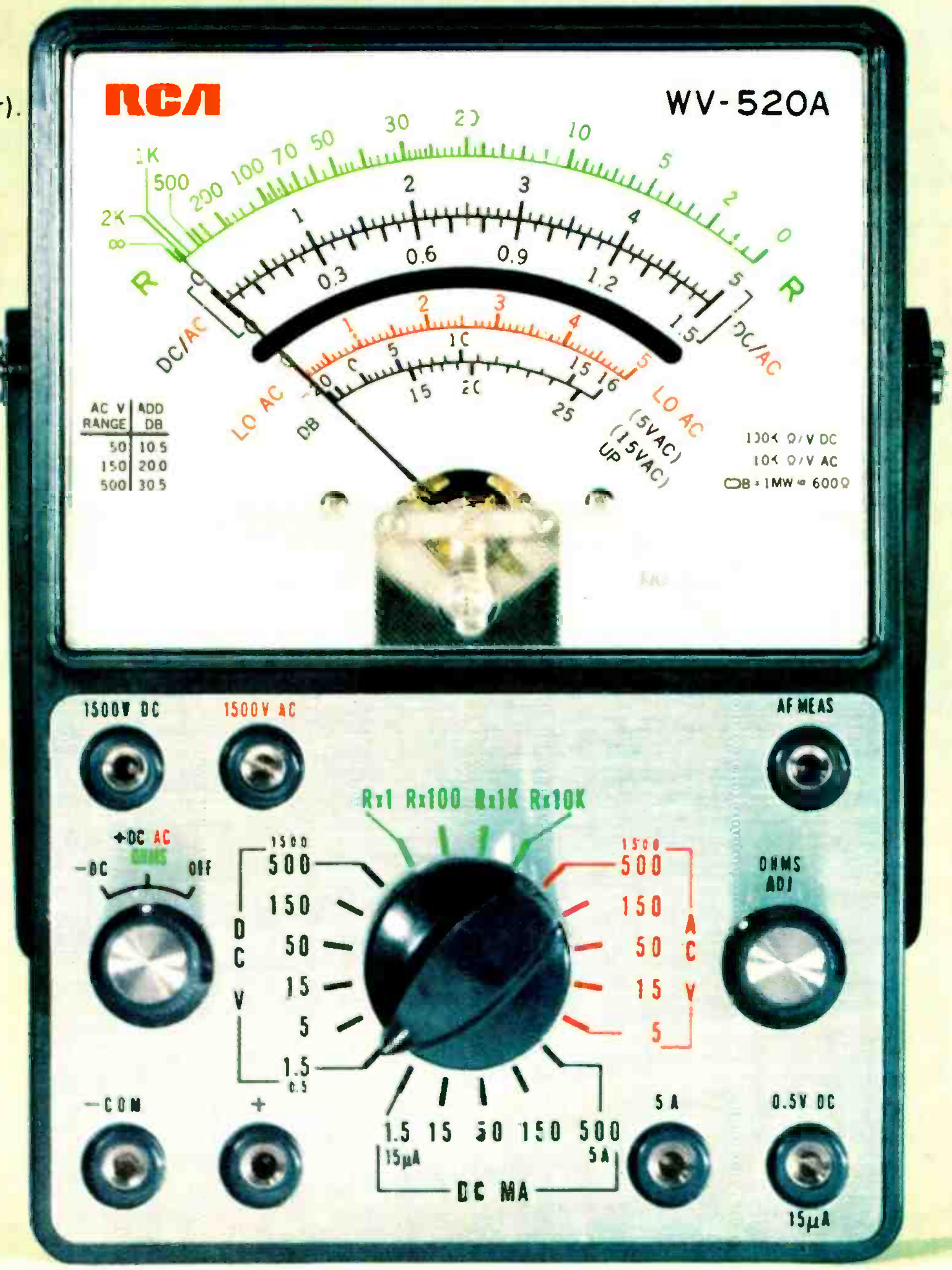
Designs For Low-Voltage Supplies

5 new RCA VOM's* Priced from $9.95** to $48.00**

*Complete with test leads, batteries and full RCA warranty (12 months parts and labor).

Input resistances from 2000 to 100,000 ohms per volt.

**Optional Distributor Resale Price



RCA | Electronic Components | Harrison, New Jersey 07029

To call it "an amplifier" would be like calling a Porsche "Basic transportation."

There is unusual satisfaction that comes from fulfilling a prosaic task in a far from prosaic manner.

Hence this amplifying system: the Sony TA-2000 professional preamplifier and the Sony TA-3200F power amplifier. Together, they perform all an amplifier's standard tasks in a satisfyingly impeccable manner; but their 67 levers, switches, meters, knobs and jacks allow you to perform some interesting functions that are anything but standard.

Dual-purpose meters.

The two VU meters on the preamplifier front panel, for example, are no more necessary than a tachometer on an automobile. But they do serve the dual purpose of simplifying record-level control when the TA-2000 is used as a dubbing center, and of allowing you to test your system's frequency response and channel separation (as well as those of your phono cartridge) and to adjust the azimuth of your tape heads.

A broadcast/recording monitor console in miniature.

The TA-2000 resembles professional sound consoles in more than its VU meters. In addition to the 20 jacks and seven input level controls provided on its rear panel for permanent connections to the rest of your hi-fi system, the TA-2000 boasts a professional patch board in miniature on its front.

Thus, you can feed the inputs from microphones, electric guitars, portable recorders or other signal sources into your system without moving the preamplifier or disturbing your normal system connections in the least. And a front-panel Line Out jack feeds signals for dubbing or other purposes into an external amp or tape recorder, with full control of tone and level from the front-panel controls and VU meters.

The tone correction and filtering facilities are also reminiscent of professional practice, allowing a total of 488 *precisely repeatable* response settings, including one in which all tone controls and filters are removed completely from the circuit.

The amplifier—no mere "black box"

A power amplifier can be considered simply as a "black box" with input and output connections, a power cord, and an on/off switch; and such an amplifier can perform as well (or poorly) as the next one. But in designing the TA-3200F Sony took pains to match the amplifier's facilities to the preamplifier's.

Thus to complement the TA-2000's two pairs of stereo outputs, the TA-3200F has two stereo pairs of inputs, selected by a switch on the front panel. Other front panel controls include independent input level controls for both channels, a speaker selector switch, and a power limiter (in case your present speaker should lack the power handling capacity of the next one you intend to buy).

Circuitry unusual, performance more so

The single-ended, push-pull output circuitry of the TA-3200F amplifier is supplied with both positive and negative voltages (not just positive and "ground") from dual balanced power supplies. This system allows the amplifier to be coupled directly to the speakers with no intervening coupling capacitors to cause phase shift or low-end roll-off (A switch on the rear panel does let you limit the bass response below 30Hz if you should want to, otherwise, it extends all the way down to 10Hz.)

The individual stages within the amplifier are also directly coupled with a transformerless complementary-symmetry driver stage, and Darlington type capacitorless coupling between the voltage amplifier stages.

As a result, in part, of this unique approach, the TA-3200F produces 200 watts of continuous (RMS) power at 8 ohms, across the entire frequency range from 20 to 20,000 Hz; IHF Dynamic Power is rated at 320 watts into 8 ohms (and fully 500 watts into a 4-ohm load).

But more important by far is the quality of the sound; intermodulation and harmonic distortion levels are held to a mere 0.1% at full rated output, and 0.03% at the more likely listening level of one-half watt. The signal-to-noise ratio is an incredible 110dB. And the full damping factor of 170 is maintained down to the lowest, most critical frequencies (another advantage of the capacitorless output circuit).

The companion TA-2000 preamplifier also boasts vanishingly low distortion and a wide signal-to-noise ratio, but this is less unusual in a preamplifier of the TA-2000's quality (and price). What *is* unusual is the performance of the phono and tape head preamplifier circuits; for though they have sufficient sensitivity (0.06mV) for the lowest-output cartridges (even without accessory transformers), these preamplifier circuits are virtually immune to overload—even with input signals 80 times greater than normal.

Their sole vice: they are hardly inexpensive

Of course, at a price of $329.50 (suggested list) for the TA-2000 preamplifier, and $349.50 (suggested list) for the TA-3200F power amp, this system cannot be considered other than a luxury. But then, it was intended to be. For there are those to whom fulfillment of prosaic tasks is unfilling. And among them are not only many of our customers, but also many of our engineers. Sony Corporation of America, 47-47 Van Dam Street, Long Island City, New York 11101.

SONY®

Porsche is a trademark of Dr.-Ing.h.c.F.Porsche KG

Circle 2 on reader service card

◄ *Circle 1 on reader service card*

NEW & TIMELY

Volume 41 Number 12 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS December 1970

HUGO GERNSBACK CRATER ON FAR SIDE OF MOON

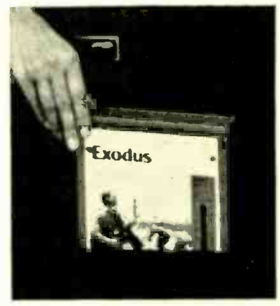
LONDON, ENGLAND—A large lunar crater on the far side of the moon has been named Hugo Gernsback by the International Astronomical Union. It is located at 36°S, 99°E. and is about 30 miles in diameter.

Hugo Gernsback, electronics and science-fiction pioneer and founder of RADIO-ELECTRONICS magazine had a long-standing interest in the moon. He often wrote about earth-to-moon communications and commercial methods of transporting lunar materials to the earth in the days when space travel was yet a dream. In 1927 he foretold, in precise detail, how man would send radio signals to the moon and pick up the reflected signals back on earth. His prediction was fulfilled in 1946.

A total of 503 persons (all deceased, except for living astronauts) were similarly honored, including science-fiction writers H. G. Wells and Willie Ley. The names were selected by the Working Group on Lunar Nomenclature, chaired by Dr. Donald H. Menzel, director of the Harvard College Observatory.

A three-sheet map of the far side of the moon with the new crater names should be available shortly from the Government Printing Office, Washington, D. C. ★

FIRST CARTRIVISION HOME UNIT

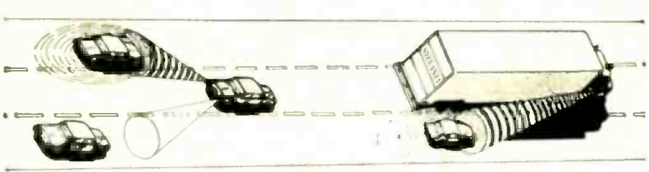


CHICAGO, ILL.—This is the first Admiral color Cartrivision console which incorporates a video tape recording/playback deck and a color-TV receiver. Shown on the screen is an actual scene from the feature film, Exodus.

The Cartrivision system can record off the air in black-and-white or color, and play back pre-recorded tapes. By setting a timer (built in) before leaving home, the owner can automatically record a TV program for later playback.

In use, a cartridge is slipped into the tape deck compartment (see closeup above) at the lower left of the cabinet. The door is closed and the unit is turned on. The recorded picture appears on the screen. ★

Highway Ultrasonics

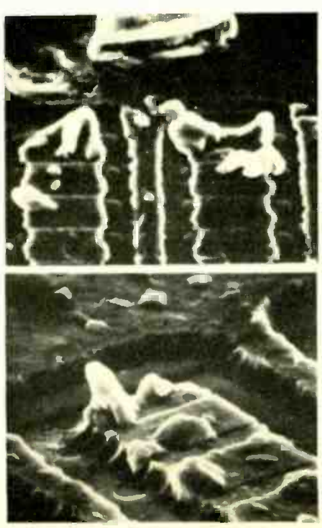


WAKEFIELD, MASS.—A prototype ultrasonic safety detector that automatically warns a driver when another vehicle is approaching from his rear has been developed.

The system, designed to be installed in a side mirror or in the rear light assembly of a vehicle, responds to noise generated by engines and tires. It flashes a warning light when a vehicle travelling at least 35 mph comes within 25 feet of the protected car.

Albert W. Peterson, engineering manager of Sylvania's Wakefield Development Laboratory, said the system has an advantage over radar and other detection systems "because it can discriminate between moving vehicles and stationary objects such as trees, poles, bridges, road dividers and guard rails."

"In operation," Peterson said, "the system suppliments existing mirrors by warning a driver that another vehicle is approaching. It is particularly helpful in fog or rain when a driver changes lanes." ★



ALUMINUM MIGRATION—A basic limitation of the aluminum metallization process in high-frequency power transistors is mass movement due to electromigration. The scanning electromicrograph illustrates the movement of metal during overstress conditions of current and temperature. The use of high-mass refractory metals in power transistors, such as those recently announced by the RCA Solid State Division, will make them less susceptible to his phenomena. The top photo shows a failure due to void formation in the metal and electrotransport. The bottom photo shows hillock growth in aluminum but no apparent electrical failure. The magnification of the top photo is approximately 1000X, and the bottom photo is approximately 2000X.

Computer Card Reader

PRINCETON, N.J.—New, light-sensitive, thin-film circuit has been developed for reading out computer punch cards electronically. Laid out like a crossword puzzle and deposited on a 4 x 8-inch glass plate the new unit is a form of integrated circuit that is about 5000 times larger in area then the standard IC.

The assembly is actually an array of 960 flat photosensitive elements, plus auxiliary components and interconnections.

According to Dr. William M. Webster, vice president, RCA Laboratories, this device "could one day replace the sensors now used to read conventional punch card." ★

(continued on page 6)

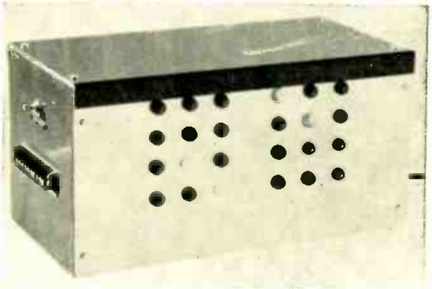
Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

December 1970 • Over 60 Years of Electronics Publishing

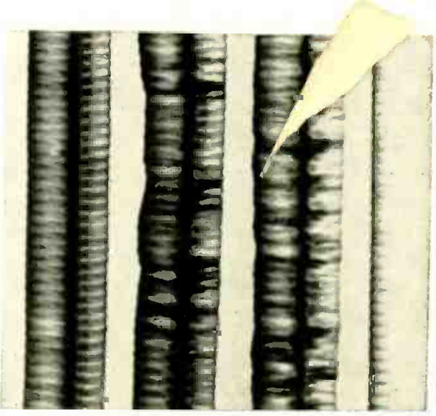
SEASON'S GREETINGS

The editors and staff of Radio-Electronics extend best wishes for the holiday season.



Electronic Umpire tells who's first—and second, and third, and fourth. Ends arguments about who won.

. . . see page 46



4-Channel Stereo Record is here from Japan. See how the proposed Victor of Japan System works.

. . . see page 45

RADIO-ELECTRONICS, Dec. 1970. Vol. 41, No. 12
Published monthly by Gernsback Publications, Inc., at 200 Park Avenue South, New York, New York 10003. Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N.Y. 10003. **Subscription Service: Boulder, Colo. 80302.** Second-class postage paid at New York City and additional mailing office. Printed in U.S.A. One-year subscription rate: U.S. and possessions, Canada, $6. Pan-American countries, $7. Other countries, $7.50. Single copies 60¢.

POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)

LOOKING AHEAD

Volume 41 Number 12 RADIO-ELECTRONICS . . . FOR MEN WITH IDEAS IN ELECTRONICS December 1970

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

Toward videoplayer standards

The worrisome problem of standards for the coming home video-player market (RADIO-ELECTRONICS, Looking Ahead, Nov. 1970) is getting some attention by manufacturers. Two of them have now come up with VTR cartridge systems which can lay some clain to being "standard."

Ampex has introduced a video tape recorder system—initially for educational and industrial use, but destined for home use later—which is compatible with the "Type I" standard for monochrome reel-to-reel recorders established by the Electronic Industries Association of Japan. How do you make a cartridge system compatible with a reel-to-reel system? Ampex did it this way: The cartridge is an enclosed reel, 4.6 inches in diameter, whose stiff plastic leader seals the unit against dust. Inserted in the cartridge player, it is automatically threaded onto a take-up reel within the player. For playing on a standard reel-to-reel recorder, an adapter is inserted in the center of the cartridge (as you'd insert a 45-rpm record adaptor), the cartridge is placed in the recorder and threaded manually.

But the Ampex has far more than that going for it. First, it's easily the most compact VTR introduced to date. The basic unit is about the size of a mini-record changer, 11 by 13 by 4½ inches. It has a carrying strap and may be operated (black-and-white mode only) on batteries. Including the batteries—flashlight or rechargeable nickel-cadmium—the basic recorder weighs only 15 pounds. For playing on ac, the unit sits on a slim base, which also may contain the color circuitry.

The basic prices established for the modular unit: Monochrome play-only, $800; monochrome record-play or color play-only, $900; color record-play, $1,000. These are prices for the first units, scheduled for marketing in mid-1971. For the eventual consumer home market, Ampex says its prices can be brought down sharply in mass production. A cartridge of half-inch tape, running at 7½ ips, plays for 30 minutes. The consumer version will feature an extended-play mode (half speed) which gets 60 minutes from the same size cartridge. We judged the picture produced by the Ampex player to be excellent, with particularly good color rendition.

A European standard

Another VTR—this one aimed primarily at home use—is also laying claim to being the "standard" system. This is Philips' "Video Cassette Recorder" (VCR), which at press time had not yet been demonstrated in the United States. But Philips has quietly been laying standardization groundwork in Europe, and agreements to build home VTR's using the Philips standard have already been signed by four major German manufacturers—Blaupunkt, Loewe Opta, Grundig and Telefunken—as well as Zanussi of Italy. Pye, a Philips affiliate in England, is expected to adopt the standard, and North American Philips (Norelco) will have a Philips-standard machine in the U.S.A.

In addition, Japanese manufacturers Sony and Matsushita (Panasonic) have agreed to work with Philips toward a standard system, at least for the European market. (Sony has a non-compatible "Video-cassette" system which is aimed at the American and Japanese markets.)

The Philips VCR is a deck, equipped with tuner for off-air recording, which will record and play back in color. The deck measures 22 by 13 by 6 inches, has two heads, includes built-in clock-timer for recording programs off-air automatically. The cassette contains two coaxially-mounted reels of half-inch chromium dioxide tape, which moves at 5.6 inches per second. Measuring 5.8 by 5 by 1.4 inches, a single cassette will play for an hour. The Philips unit will sell for $500 to $600 when it is first marketed in the U.S.

Wonders of Selecta-Vision

While other manufacturers prepare video recorders for the market, CBS and RCA continue to concentrate on playback-only systems—EVR and Selecta-Vision, respectively. The first EVR players are already coming off the production lines of CBS licensee Motorola. Selecta-Vision isn't scheduled for production until 1972, but not only is RCA confident it can produce this laser-holography playback system, it's already looking to second and third generation Selecta-Vision machines.

In an article in *EBU Bulletin*, published by the European Broadcasting Union, RCA researchers say that Selecta-Vision's unique properties hold the promise of these advances: (1) The 180-hour video cartridge. Since holograms may be superimposed on one another by changing the angle at which they are recorded, one cartridge might be recorded 360 times at different angles to provide a full week's playing time. (2) Stereoscopic TV. 3-D holograms, says RCA, can be pressed into Selecta-Vision tape as easily as 2-D ones, but a suitable viewer or home projection system must be developed to make possible home stereoscopic playback. (3) Life-size images. By using Selecta-Vision tapes with bright external laser light source, pictures could be projected directly onto a large screen.

Electronic detectives

Electronic devices are taking an increasing share of the $1-billion annual market for surveillance and detection equipment. And at the recent International Security Conference meeting and exhibit in New York, there was strong evidence that price reductions in watchdog equipment are bringing it within reach of many homeowners.

For example, both Mallory and Delta Products are offering ultrasonic intrusion detectors, designed to protect a single room—Mallory for $89.95, Delta's for $69.95. A similar system designed to protect an entire home is being introduced by Control Dynamics Co. at about $250. Being pushed by Record-O-Fone is a telephone gadget which automatically dials the police and reports a burglary, for $395. Activating switches for doors and windows are not-so-optional extras.

One of the most intriguing security gadgets is the Video Sensor, introduced by GBC Closed Circuit Corp., for use with any existing closed-circuit TV system. It comes with two light sensors, to be affixed by suction cup to the face of the monitor screen. When any motion occurs on the portion of the screen covered by the sensors, an alarm is triggered. If a picture of the intruder is desired, a film or VTR camera is also activated. **R-E**

Circle 3 on reader service card

(Continued from page 2)

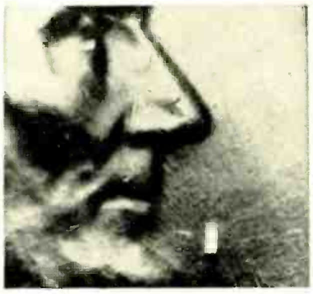
NEW!—Continuous Room Temperature Solid-State Laser

"One of the most important scientific events of the year is the development of a solid-state laser that operates at room temperature!"

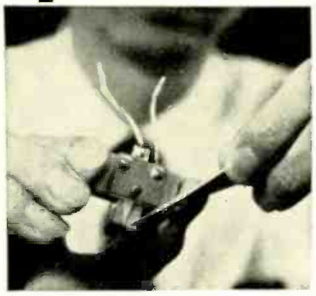
That statement will not electrify many readers. A few will ask "Just what is a laser?" The more blasé are likely to ask: "Why all the excitement? They have been operating gas lasers at room temperatures for nearly ten years."

Answering the questions in order: a laser is a light-producing device. Light, like radio, is an electromagnetic radiation. But radio emissions, unlike light, tend to travel in coherent *waves*. Like the waves set up by that pebble thrown into the lake on page one of our first radio textbook, they spread out evenly in all directions from a common point—or march straight ahead from a directive antenna. If you put up measuring apparatus, you could find that the wave from a broadcast station—say one at 1,000 kHz (1MHz) would be highly positive at a given instant. A half-millionth of a second later, it would be highly negative, and at the next half-millionth would be positive again. (The best measuring setup would be an antenna, a receiver and an rf frequency counter.)

Ordinary light doesn't work like that. It can better be represented by a shovel of gravel thrown over a broad patch of the lake. Waves would be set up, but they would be confused and *incoherent*.



NEW LASER (.003 x .015 in.) resting below Lincoln's nose on a copper penny.



MOUNTED IN HEAT SINK, the tiny laser (at tip of the pointer) draws about 1.5 W.

The laser lines up all the particles that make up the light radiation and gets them to march in step. A strong beam of light (in the first ruby laser), a radio field (in the gas laser) or an electric voltage in the solid-state laser, knocks some of the atoms in the active material out of their regular orbits in the atom. (The active material is the ruby, the gas, or a layer of the semiconductor.) These electrons fall back into place almost immediately, and give up the energy that knocked them out of orbit in the form of a tiny burst of light—a photon. As the photon starts traveling, it knocks other displaced atoms back into orbit, and stimulating other outbursts of light. This is *amplification*-using light to increase light. Incidentally the laser is named after this action: Light Amplification by Stimulated Emission of Radiation.

Lasers are built long and narrow, so that the light traveling lengthwise of the laser is amplified as it travels. Photons traveling crosswise soon leave the laser and don't complicate the issue.

Light built up this way can become tremendously powerful—the strongest beams of light known to man. Even more important, those beams can be controlled to a great degree of accuracy. The beam width of lasers has been controlled to .05°. This is ten times as sharp a pattern as can be obtained with a good directive radio antenna system. Lasers would be ideal for communication by light (one of the oldest forms of long-distance communication, by the way). And this brings us to the next question: Why all the excitement?

There is a reason for excitement. With the continuous and increasing crowding of the communications frequencies, researchers have been eyeing the fantastic spectrum above our conventional millimeter waves. And it *is* fantastic. Suppose we try to draw it to scale, using one-tenth of an inch for 1 MHz. That is, all the frequencies below the middle of the broadcast band would be crowded into the left-hand 0.1 inch of our scale drawing. Then 100 MHz, the middle of the FM band, would be 10 inches along the scale, and 1,000 MHz (1 GHz) 100 inches, a little more than 8 feet. Now to get to 1 terahertz (1,000,000 MHz), we have to extend our scale about a *mile and a half!* And we are just at the beginning of the infrared range, which extends some 450 THz ahead of us, or nearly 700 miles. And every inch in this 700 miles can carry the same amount of communication as in all the frequencies below 100 MHz (if we can build equipment to take full advantage of the spectrum). So the laser band *is* an important one.

As one Bell scientist

(continued on page 14)

Radio-Electronics

HUGO GERNSBACK (1884-1967) founder

M. HARVEY GERNSBACK, *editor and publisher*

LARRY STECKLER, *managing editor*

Robert F. Scott, *W2PWG senior technical editor*

Jack Darr, *service editor*

I. Queen, *editorial associate*

Matthew Mandl, *contributing editor*

David Lachenbruch, *contributing editor*

Joan Washington, *editorial assistant*

Vincent P. Cicenia, *production manager*

Barbara Rosefelt, *production assistant*

H. Matysko, *circulation*

Cover design by Marius Trinque

Cover photo by Phil Hanek

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
200 Park Ave. South
New York, N.Y. 10003
(212) 777-6400
President: M. Harvey Gernsback
Secretary: Bertina Baer

ADVERTISING SALES

EAST
Stanley Levitan, Eastern Sales Mgr.
N.Y.C. (212) 777-6400

MIDWEST/Texas/Arkansas/Okla.
Ralph Bergen,
6319 N. Central Ave.
Chicago, Ill. 60646
(312) 792-3646

PACIFIC COAST/Mountain States
J. E. Publishers Representative Co.,
8560 Sunset Blvd., Suite 601
Los Angeles, Calif. 90069
(213) 659-3810
420 Market St. San Francisco, Calif. 94111, (415) 981-4527

SOUTHEAST
E. Lucian Neff Associates
25 Castle Harbor Isle
Fort Lauderdale, Florida 33308
(305) 566-5656

SUBSCRIPTION SERVICE: Send all subscription orders and correspondence to RADIO-ELECTRONICS, Subscription Department, Boulder, Colo. 80302.

MOVING? For change of address, allow six weeks, furnishing both the old and new addresses and if possible attaching label from a recent issue below. Otherwise please print clearly your name and address exactly as it appears on your label.

ATTACH LABEL HERE

name (please print)

address

city state zip code

Mail to: RADIO-ELECTRONICS
SUBSCRIPTION DEPT., BOULDER, COLO. 80302

NOW train at home with NRI to be a Computer or Digital Technician– no other program is so complete in digital logic, computer operation and programming.

ANOTHER NRI FIRST

Your own digital computer included at no extra cost

This may very well be the most unique educational aid ever developed for home training— a *real* digital computer you build yourself and use to learn organization, operation, trouble shooting and programming. This remarkable training aid performs the same functions as bigger commercial computers. One of ten training kits you receive in the new NRI Complete Computer Electronics course.

EQUIPMENT REPORT

Sencore FE-14 FET Meter

For manufacturer's literature, circle No. 20 on Reader Service Card.

By using field-effect transistors, (FET's) we can get a "FETVM" that is no bigger than a VOM, but with the VTVM's very high sensitivity; higher, in fact. The Sencore FE-14 is a good example. Battery-operated, it is only 5 x 7 inches in size, and it can be set anywhere. Without the ac line connection, you have gotten away from this problem in any kind of transistor gear. The meter used is a 4.5-inch unit, big enough to read at good distances.

With an input impedance of 15 meg-ohms for dc voltages, and 10.0 megohms for ac, plus a frequency response flat out to several MHz, you can get useful readings in many circuits which have been difficult if not impossible to check up to now.

With its frequency-compensated attenuator, the FE-14 can be used to read *signal* voltages through transistor amplifiers, even up into the TV i.f. range. Since "signal-tracing" is one of the handiest ways of pinpointing trouble in PC-board solid-state things, this can be very valuable.

The 0-1 volt dc volts scale is very handy for reading transistor bias voltages. The FE-14 also has current ranges from 100 microamperes up to 1.0 ampere (nice for reading the 200–300 mA currents in color sets, putting the reading very close to center-scale). A simple shunt (Fig. 1, consisting of 2 feet of No. 20 copper wire wound on a ¾-inch dual banana plug) can be made to extend the range up to 10 amperes for auto-radios, high-power transistor amplifiers, etc.

It can be set to read "zero-center" on any dc voltage scale, by simply setting the ZERO ADJ control. This gives you zero-center ranges from +0.5 volt to −0.5 volt, up to −500 to +500 volts. Saves a lot of lead-reversing in transistor circuits. A polarity-reversing position is also included on the selector switch.

Accuracy seems to be very good. On OHMS, I checked it against my pet 1.0-meg 1% resistor and it was right on the nose. Ac and dc volts scales checked out against my other vtvm's which are in good shape.

With a separate high-voltage probe using a 1,485-megohm resistor, you can read "100 times" on all dc voltage scales. This gives you a 30,000-volt full-scale for color HV, a 10-kV range for setting and checking focus voltages, and a 3-kV range for checking that 1100–1200-volt boosted-boost used in a lot of color circuits.

Ac voltages can be read as rms or as peak-to-peak, without any trouble, by checking the special p-p scale on the meter. No switching or special probes are needed.

All in all, a very handy little meter, and one that should be valuable in the service shop. The "price is right" too. **R-E**

COMING NEXT MONTH

JANUARY 1971

SPECIAL ISSUE COLOR TV

- **How Color TV Works**
  See how those beautiful color pictures get from the studio to your TV screen.
- **Check Color TV X-Rays**
  $25 detector tells you if you're getting too much radiation from your set.
- **Remote Control For Color**
  Programmed text shows how color TV remote controls operate and provides hints for servicing.
- **Test Equipment For Color**
  Service Editor Jack Darr talks about the equipment you must have and what it will do for you.

PLUS . . .

Computer Logic Laboratory
Designing Solid-State Stereo Amplifiers
Jack Darr's Service Clinic

Circle 6 on reader service card →

(Continued from page 6)

said, very conservatively: Such lasers, operating at room temperature, may one day speed the transmission of voice, data, and other information signals in high-capacity optical communications systems," and went on to say that semiconductor lasers may also have a significant impact on the new technology of optical electronics.

Now, why has it been impossible to operate a solid-state laser at room temperatures? The answer is in the tremendous amount of power needed to start (and continue) laser action. The semiconductor laser requires an enormous amount of current—up to a couple of years ago as much as 20,000 amperes per square centimeter. So they could be operated only intermittently—in short pulses—without burning up.

What Bell scientists Izuo Hayashi and Morton Panish did was to fabricate a new semiconductor laser structure that could be driven by a smaller electric current. The successful laser consists of four layers of semiconductor material, two of them gallium arsenide and two of gallium aluminum arsenide. A thin gallium arsenide layer, only 0.45 micron thick, is the *active region*. By confining laser activity to such a small region, the current necessary to produce laser activity can be kept lower.

The very thinness of the laser also makes it possible to radiate heat away from it more effectively. And its other dimensions are small—the laser is only about 15 thousandths of an inch long by three thousandths wide. The whole laser is clamped between heat-dissipating elements.

The resultant laser can be operated with an ordinary flashlight cell, taking a little less than an ampere at 1.5 volts. Efficiency is low, about 2% at best, and output in the early experimental models reaches a maximum of about 20 milliwatts.

At first this does not look much better than the gas laser, though of course the semiconductor type is far less complicated and expensive to operate. But Bell remembers the first transistors, not so many years ago. Not only was their power extremely limited, but their frequency response was limited to the audio range. Now one can buy a transistor rated at over a hundred watts, and transistors are rated up into the gigahertz range. The new laser is at exactly the same point as the transistor was a scant 20 years ago.—*Fred Shunaman*

TV X-RAY DETECTORS

PHILADELPHIA, PA.—The U.S. Department of Health's Division of Electronic Products has developed two simple tube instruments from common, inexpensive components and are being suggested for use by TV service technicians to detect emission of X-rays from TV receivers.

One instrument is a low-cost detector that indicates whether a receiver is emitting excessive X-rays. The unit is easily assembled and many of the components can be found in a technician's "junk box". It requires no calibration.

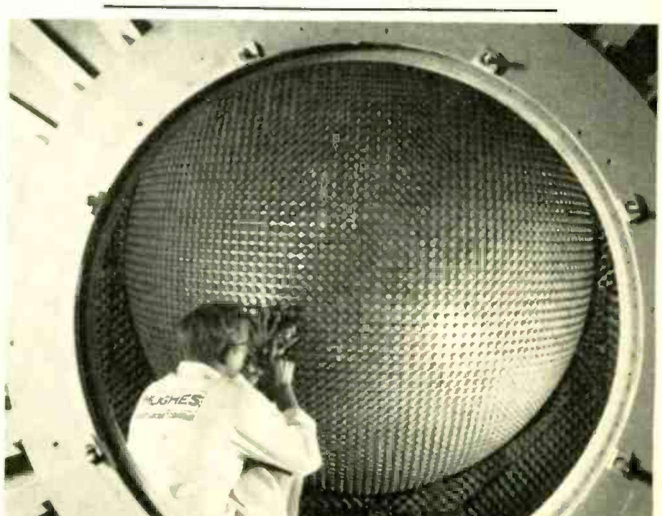
The second instrument is more complex, designed for those wishing to construct a high quality Geiger-Mueller instrument for which checkout and calibration require only commonly available service shop instrumentation.

SCANCONVERTER FOR AIR TRAFFIC

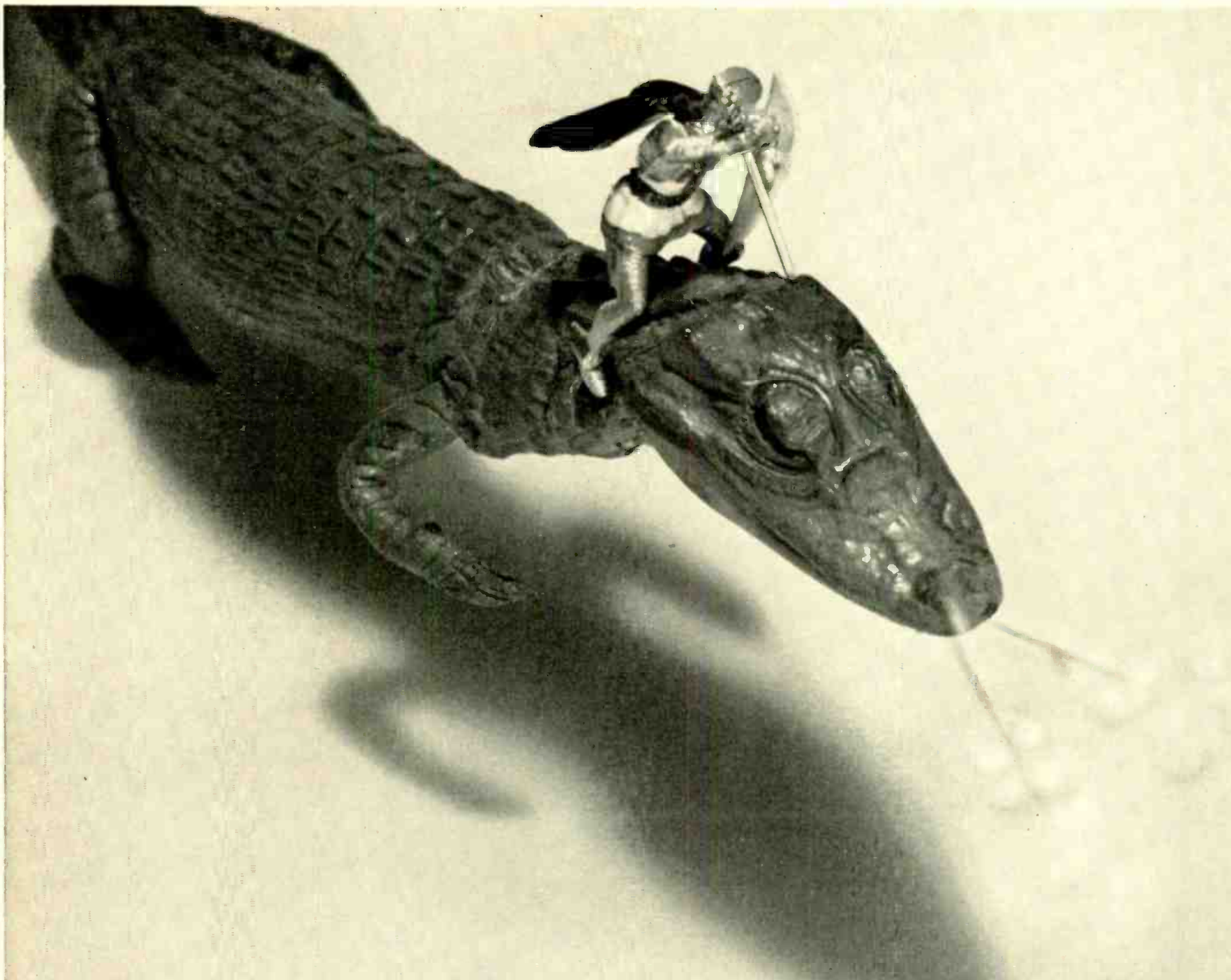
BALTIMORE, MD.—Engineering model of radar bright display equipment will be used for air traffic control by the FAA. The equipment will be used to expand services of the federal agency's air route traffic control centers.

Radar bright display equipment transforms air traffic control radar and beacon information into television presentations that can be seen under normal lighting.

When radar and beacon information is displayed on a standard plan position indicator (PPI), the light in the area of the display must be reduced to near darkness in order to see the indications on the display. Radar bright display equipment enables controllers to work in normal light conditions. This new unit is being built by Westinghouse.



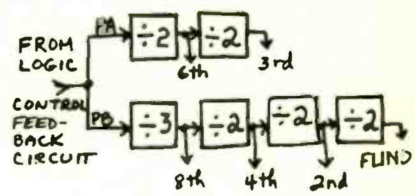
NEW RADAR—Framed by its reflector assembly, energy feeds on the receiving antenna of an advanced radar prototype are adjusted by an engineer at Hughes Aircraft Company, Fullerton, Calif., prior to final testing. The energy feeds are devices that channel radio-frequency energy between points in the system. The prototype, called ADAR (for Advanced Design Array Radar), is undergoing final tests at an isolated mountaintop facility to check out the radar's over-all concept, stability and reliability. ★



Correspondence

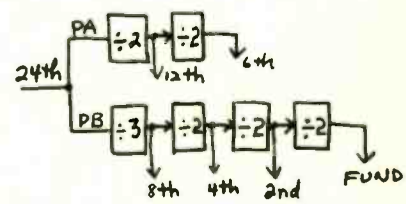
DIGISYNTONE SLIP

There is a mistake in Fred Maynard's article "Build a Digisyntone" September 1970. He says that the output from the logic control feedback circuit is divided into two paths. Path PA is divided by 2 to get the 6th harmonic, and by 2 again to get the third harmonic. Path PB is divided by 3, add by 2 three times to get the 8th, 4th and 2nd harmonics, and the fundamental as shown here.

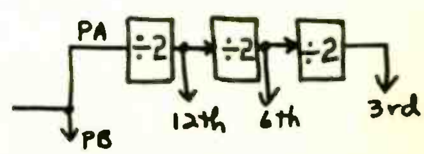


This is partly wrong. Since the input was divided by 3 (in path PB) to get the 8th harmonic, I would conclude that the input is actually the 24th harmonic of the fundamental.

But in path PA, this same input is divided by 2 to get the 6th harmonic. This could not be true. Therefore, what the article states to be the 6th harmonic, is actually the 12th—and what it states to be the 3rd harmonic, is actually the 6th.



Of course the Digisyntone will work this way, but those who build it would be gypped out of the true 3rd harmonic. To get the third harmonic, another divider would have to be added as shown here. You would also have to add another attenuator con-



(continued on page 22)

Sams Books famous for Servicing Know-How

Hi-Fi Stereo Servicing Guide

by ROBERT G. MIDDLETON. A complete guide to effective servicing of a-m tuners, fm tuners, stereo-multiplex units, and audio amplifiers (all components, except record players and tape recorders). Includes hi-fi speaker system installations, trouble localization, and overall system evaluation. Also gives testing methods for verifying performance.

Order 20785, *only* $3.95

Radio Receiver Servicing Guide

by ROBERT G. MIDDLETON. Presents the professional technician's approach. Covers troubleshooting and repair of a-m radio receivers, both solid-state and tube type. Methods for quick localization of troubles in any circuit are explained in detail, along with the proper use of test equipment. Includes a fascinating final chapter on the restoration of antique radio receivers.

Order 20790, *only* $3.95

Record Changer Servicing Guide

by ROBERT G. MIDDLETON. Presents the general principles of record changer design, followed by a detailed analysis of the working parts of changer mechanisms. Explains adjustment and lubrication procedures, diagnostic techniques for operating troubles, and the corrective measures required to remedy them. This is a thoroughly practical guide.

Order 20730, *only* $3.95

Tape Recorder Servicing Guide

by ROBERT G. MIDDLETON. Tells how to repair tape recorders profitably. Thoroughly explains the principles and characteristics of magnetic recorder circuitry, describing the various components and systems. Provides full instructions on preventative maintenance, adjustments, and proper solutions to tape transport, recording, and reproduction troubles.

Order 20748, *only* $3.95

Color TV Servicing Guide

by ROBERT G. MIDDLETON. Shows how to apply fast troubleshooting techniques to color-TV repair using the famous Middleton system based on analysis of trouble symptoms illustrated by actual full-color picture tube photos. Clearly-written text explains possible trouble causes and diagnostic procedures. Final chapter explains in detail how to use color-bar generator.

Order 20358, *only* $4.25

Transistor Color-TV Servicing Guide

by ROBERT G. MIDDLETON. Clearly explains the basics of the various circuits used in transistor color-TV receivers, including the most recent developments. Shows how to apply proper troubleshooting procedures based on analysis of trouble symptoms. Includes a wealth of circuit diagrams, charts, and picture tube and waveform photographs.

Order 20693, *only* $4.50

Transistor-TV Servicing Guide

by ROBERT G. MIDDLETON. Second edition. Updated to provide full information on latest circuitry and many additional new test procedures. Clearly explains general transistor circuitry and servicing techniques and then proceeds through the receiver, section by section, describing various picture and or sound trouble symptoms and their remedies.

Order 20696, *only* $3.95

TV Servicing Guide

by LESLIE D. DEANE and CALVIN C. YOUNG, JR. This is the famous guide used by more than 100,000 service technicians. Shows you how to apply quick troubleshooting procedures based on analysis of trouble symptoms illustrated by picture tube photos. Fully explains possible causes for each trouble symptom and then details proper diagnostic and repair procedures.

Order 20361, *only* $3.25

HOWARD W. SAMS & CO., INC.

Order from your Electronic Parts Distributor,
or mail to Howard W. Sams & Co., Inc., Dept. RE-120
4300 W. 62nd St., Indianapolis, Ind. 46268

Send books checked at right. $______ enclosed

☐ Send FREE 1970 Sams Book Catalog

Name____________________

Address____________________

City__________ State______ Zip______

☐ 20785
☐ 20730
☐ 20790
☐ 20748
☐ 20358
☐ 20693
☐ 20696
☐ 20361

Circle 10 on reader service card

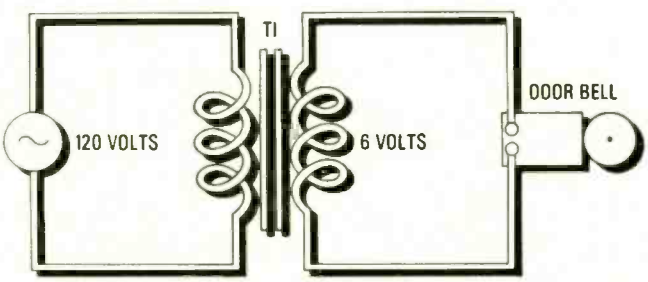
Second in a series...

Can you solve these problems in electronics?

They're a cinch after you've taken RCA Institutes' new communications electronics program.

It includes new preparation for the FCC license plus the assurance of your money back if you fail to get it.

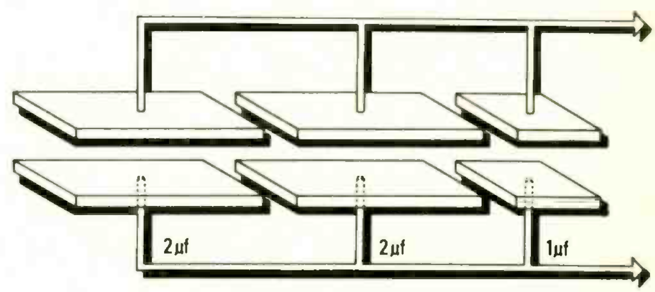
This one is quite elementary.



In this door bell circuit, which kind of transformer is T_1 — step-up or step-down?

Note: if you had completed only the first lesson of *any* of the RCA Institutes Home Study programs, you'd easily solve this problem.

This one is more advanced.



What is the total capacitance in the above circuit?

Note: you'd know the solution to the problem if you'd taken only the first two lessons in RCA's new Communications Electronics Program.

These are the lessons that prepare you step-by-step for an FCC License.

This license is a requirement for servicing all types of transmitting equipment and can help open doors to jobs commanding high income in communications, radio and broadcasting, aerospace, industrial automation and many others.

For a rewarding career with good pay, take that first step now. Send for complete information—mail the attached card.

Answers: Step-down.
5 µf

RCA Institutes Autotext learning method makes problem-solving easier... gets you started faster towards a good-paying career in electronics

Are you just a beginner with an interest in electronics? Or, are you already making a living in electronics, and want to brush-up or expand your knowledge? In either case, RCA has the training you need. And Autotext, RCA Institutes' own method of Home Training will help you learn more quickly and with less effort.

Wide Range of Courses

Select from a wide range of courses. Pick the one that suits you best and check it off on the attached card. Courses are available for beginners and advanced technicians.

Electronics Fundamentals
Black & White Television Servicing
(Transistorized TV Kit Available)
Color Television Servicing (Color TV Kit Available)
FCC License Preparation
Automatic Controls
Automation Electronics
Industrial Electronics
Nuclear Instrumentation
Electronics Drafting
Computer Programming

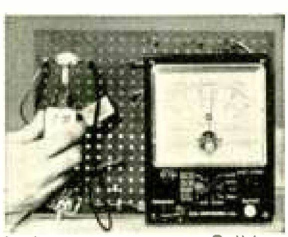
Build and keep this valuable oscilloscope.

Plus these new up-to-the-minute courses

Semiconductor Electronics
Digital Electronics
Solid State Electronics
Communications Electronics

Prepare for good paying positions in fields like these

Television Servicing
Telecommunications
Mobile Communications
CATV
Broadcasting
Marine Communications
Nuclear Instrumentation
Industrial Electronics
Automation
Computer Programming
Solid State
Electronics Drafting



In the new program on Solid State Electronics you will study the effects of temperature and leakage characteristics of transistors.

RCA

Variety of Kits—Yours to Keep

A variety of RCA Institutes engineered kits are included in your program of study. Each kit is yours to keep when you've completed the course. Among the kits you construct and keep is a working signal generator, a multimeter, a fully transistorized breadboard superheterodyne AM receiver, and the all-important oscilloscope. These 4 kits are at no extra cost. Compare this selection with other home study schools.

Two Convenient Payment Plans

Pay for lessons as you order them. No contract obligating you to continue the course. Or, you can take advantage of RCA's convenient monthly payment plan. No interest charges!

Classroom Training Also Available

RCA Institutes operates one of the largest technical schools of its kind. Day and evening classes. No previous training is required. Preparatory courses are available. Classes start four times a year.

Job Placement Service, Too!

Companies like Bell Telephone Labs, GE, Honeywell, IBM, RCA, Westinghouse, Xerox, and major radio and TV networks have regularly employed graduates through RCA Institutes' own placement service.

All RCA Institutes courses and programs are approved for veterans under the new G.I. Bill.

Send Attached Postage Paid Card Today. Check Home Study or Classroom Training.

Accredited Member National Home Study Council.

IF REPLY CARD IS DETACHED, SEND THIS COUPON

RCA Institutes Inc.
Home Study Dept.758-012-0
320 West 31 Street
New York, N.Y. 10001

Please send me FREE illustrated career catalog.

Name ____________________ Age ______
(please print)
Address ____________________
City __________ State __________ Zip ______

Circle 11 on reader service card

Circle 12 on reader service card

CORRESPONDENCE
(continued from page 16)

trol and make an addition to the filter system.
KURT BIGLER
Rittman, Ohio

CURVE TRACER METHOD NOT NEW

I'm writing in reference to the June 1970 article "Troubleshoot TV With A Transistor Curve Tracer." With all due respect to Mr. Williams, this technique is certainly not new to anyone who has a curve tracer. We here at NASA have used this technique for a number of years. This technique would be more universally used if it were not for the fact a good curve tracer is beyond the reach cost wise of the average technician. Home-made units mated to the x-y of a scope tend to introduce phase distortion which is usually intolerable.
NORMAN MELNYK
Cleveland, Ohio

Hold it right there. The technique may have been known for quite a while, but Jud Williams is about the first to make it known to that average technician you spoke about. Also, for troubleshooting purposes, it is not necessary to have an exact, precise, waveform display to be able to determine if the transistor is good or bad.—Editor

CRUSADE GOES ON

Jack Darr's Crusade seems to have died out. Can you tell me what's been happening?

The crusade is far from dead. We've accumulated quite a file of case histories and would like to receive more. Tell us about your problems in getting parts to do a repair job. You can expect a further report in January.
—Editor **R-E**

"It seems to me that anyone who could build a color TV from a kit could put a new light bulb in the kitchen."

In the Shop . . . With Jack

By **JACK DARR**
SERVICE EDITOR

IMAGINATION

Given the same test instruments—voltmeters, signal generators, and scope—plus a good knowledge of the circuitry, what's the one thing that makes the difference between a run-of-the mill technician and the real expert? IMAGINATION!! Sound silly? Not at all.

A lively imagination is vital, and even the less-skilled technicians use it without knowing that they are! Let's kick this around for a while. What is the hardest part of this job? The part that takes the real *skill?* The *diagnosis.* Electronic maintenance is 95% diagnosis and 5% "execution" (replacing the bad part).

Diagnosis is 100% mental. We get a few facts about the nature of the fault from direct observation of the symptoms. The most unskilled man in the world can make the initial observation *"It doesn't work!"* Next is *"What doesn't work?"* Using the oldest method known, the technician then follows a logical step-by-step procedure to identify the faulty part. Four steps—Function, Stage, Circuit, Part.

All TV sets, for example, have the same functions—horizontal sweep, dc power supply, and so on. All *Functions* are made up of *Stages*—horizontal oscillator, output, damper, flyback, yoke, etc. All *Stages* are made up of *Circuits*—plate circuit, collector circuit, grid circuit and so on. All *Circuits* are made up of *Parts*—resistors, capacitors, wires (and solder joints!). There's the pathway. All we have to do is follow it.

So where does the imagination come in? In the *speed* with which we follow this path. The expert looks at the problem, makes a few measurements to get some facts, and then his busy little brain starts clicking. He says to himself, "What if ———— has happened?" and dives for a certain circuit. His imagination has aimed him straight at the circuit that is the *most likely cause* of the trouble.

He has made a mental list of the things that he can imagine as the cause of the symptoms he sees. Then he checks these out, impartially. Without this vital factor it's just a dull, plodding routine of disconnecting every part in the circuit, testing it and putting it back. (How many men do you know who work just like this? In fact, how many times have *you* done it? Be honest now!)

Using the plod or shotgun method, he'll find the trouble, eventually. BUT! using a trained imagination can get the job done a lot faster.

As in all other pathways, there are pitfalls in this one too. One thing you must watch out for is the closed mind—the fixed opinion with no factual basis. When our expert goes after the trouble, he keeps a completely open mind. He doesn't care what is causing it; he just wants to find it. So his thinking is much clearer and more effective. "Prejudice," by the way, is a very good word for this since it comes from a Latin root meaning "making up your mind before you have all the facts!" Judging in advance, that is.

Example of prejudice in action—we look at a problem and say "Oh yes. This is a bad plate load resistor! I *know* it is!" After this, all of your tests are subconsciously aimed at proving yourself right. Not at finding the real cause of the trouble! We're actually trying to prove to ourselves how smart we are. We're going to find a bad plate resistor in there if it takes us all day. (And it may do just that, with such an impediment to clear thinking. Come on now, 'fess up. How many times have *you* done just that? I know that *I* have on far too many occasions.)

Therefore, we simply have to keep an open mind while doing this kind of work. It isn't easy. You have to watch yourself like a hawk. But after all, what is the object of this little exercise? To fix the set—get it working again. By the time we get through with our preliminary observations and tests, we'll have narrowed it down to about 8 or 10 parts at the most. So what difference does it make *which* one of 'em is bad?

When we begin the final steps of the analysis, we know the nature of the fault. Let's say it's a loss of dc voltage at a key point. Now, Imagination says, "Well, this is either an open circuit or a short. These are the only things that could give me the symptoms I see." Now we imagine what a short would do—overheat some resistors, blow a fuse, burn wires, etc. We hold a cautious fingertip near a big resistor. If it's cool or not too hot, we drop the "short" possibility and go looking for the open circuit that is now the most logical suspect. Inside of a very short time we have the culprit by the heels and drag him out into the light.

So that's the practical value of a lively, well-trained imagination. We can look at a defective TV, or anything else for that matter, and say to ourselves, "Now what could cause this?" Instantly, the imagination goes to work, making out a list of troubles which could give us

(continued on page 82)

HOME APPLIANCE ELECTRONICS

by JACK DARR

Home appliance repairs are starting to turn into electronic repairs, thanks to the steadily growing amount of electronic circuitry finding its way into refrigerators, washers, driers, etc.

These repairs are relatively simple, especially when compared to intermittent troubles in a color TV receiver.

So we're trying an experiment. We've asked Service Editor Jack Darr, who has written several books on appliance repairs to do this column. If it goes over well in terms of reader response, it will continue in future issues. If it doesn't, we'll call it quits—for now. So let's hear from you.

SAY "ELECTRONICS" TO US AND WE usually think of TV, radio, and the like. However, you'll find electronic circuits, principles and badgetry being used more and more in other things, beside the "entertainment" uses we are familiar with. You'd be surprised at how many purely electronic, (as compared to strictly "electric") things and applications you can find now.

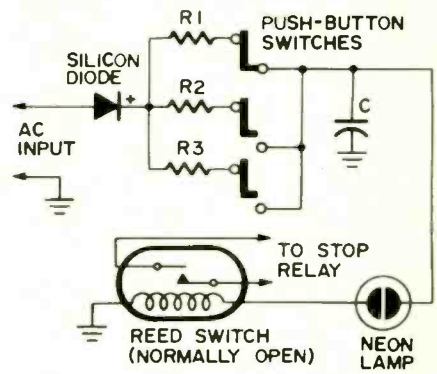
This just might make up a very useful new field of endeavor for us. If you'll check, you'll find that the electronic circuits used are extremely simple. At least, they look simple to the guy who spends his days digging around in the bewildering complexity of color TV, stereo decoders, ultrasonic remote control systems, and that kind of stuff.

For example, the Maytag Co., of Newton Iowa, probably the oldest maker of washers and driers in the country, have been using a very simple, purely electronic control circuit on their automatic driers, for some time. The basic circuit is in the diagram. It provides an automatic cut-off for the drier for different types of fabrics.

The circuit action is as follows; when the unit goes into the timed phase of the dry cycle, the rectifier is switched into the circuit. This develops a dc voltage which is applied to the capacitor, through one of several different value resistors. The correct resistor is selected by one of the push-button switches on the panel.

The capacitor starts to charge. The time-constant of this, of course, is plain old "RC"—value of the resistor multiplied by the size of the capacitor. In a given length of time, the charge on the capacitor will reach a certain percentage of the charging voltage.

A neon lamp is connected to the capacitor. As most of us know, these lamps fire at about 67 volts. The other side of the lamp, returns to ground through the coil of a reed switch. It takes only a very small current pulse to make these switches close.

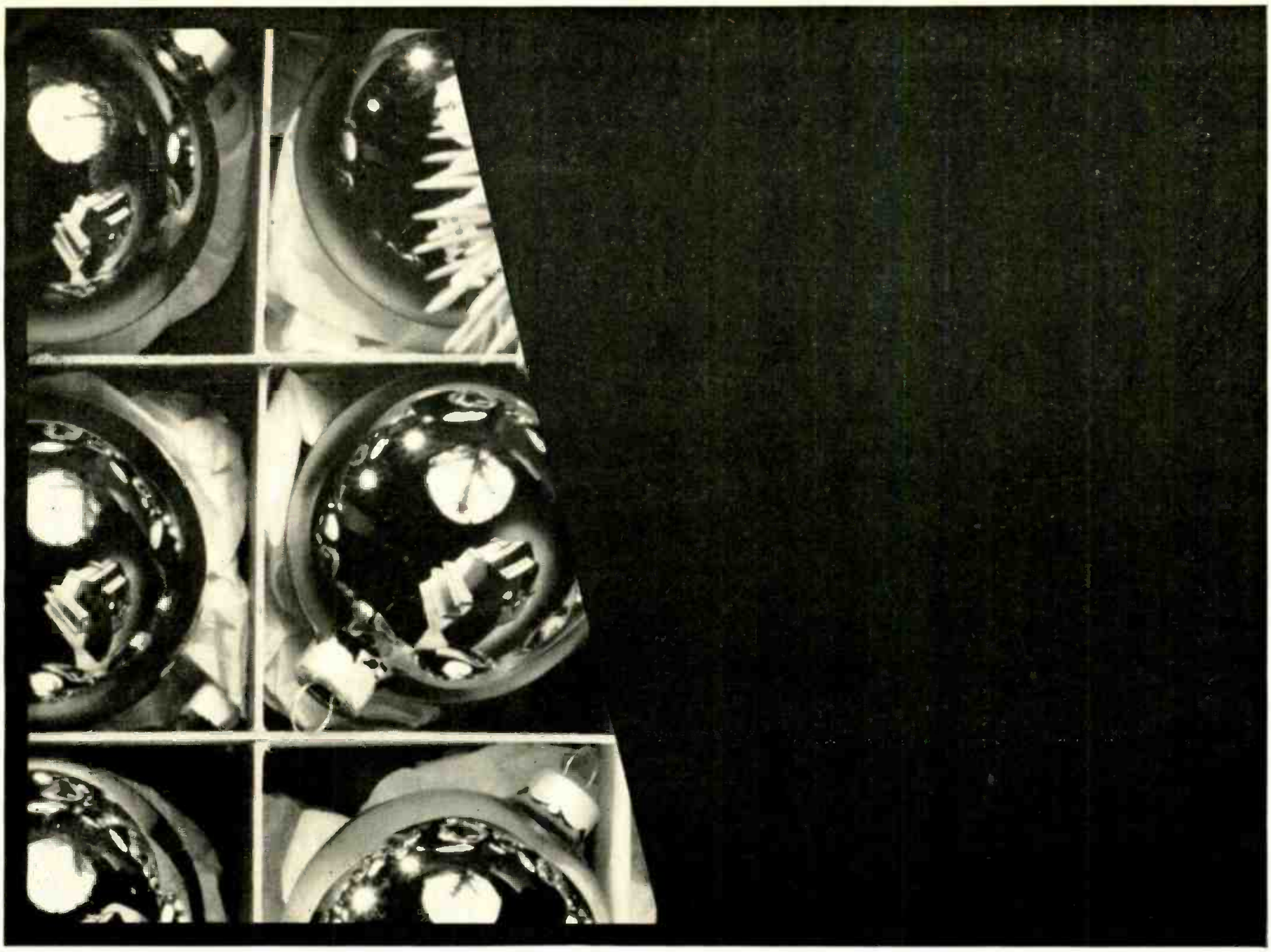


When the dc voltage on the capacitor has reached the necessary level, the neon lamp fires. This allows a small pulse of current to flow through the reed-switch coil, closing the contacts. When these contacts close, they actuate another (heavier) relay, which has been holding the heating elements, motor, etc. in an ON condition while the drier runs. This relay now opens, stopping the drier.

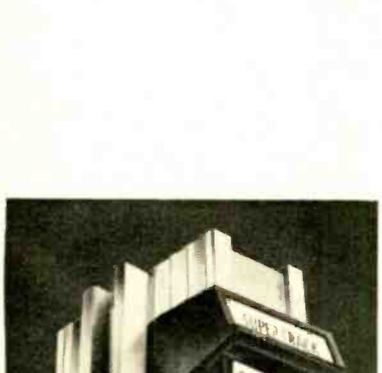
That's all there is to it. To get a longer running-time, a larger resistor is switched in, and vice versa. This is about as simple as you can get, and it's worked for some years.

Most of the "home electronics" are equally basic. You'll find quite a number of different things, from SCR lamp-dimmers to timing controls of different kinds, temperature controls, and on and on.

In fact, these things are getting so popular that Radio-Electronics has been thinking about opening a branch office of the Service Clinic. We might call it the Home Electronics Clinic. Let us know what you think about this. If you have run into problems in this area, send them in and we'll see what we can do about them.—*Jack Darr.* **R-E**



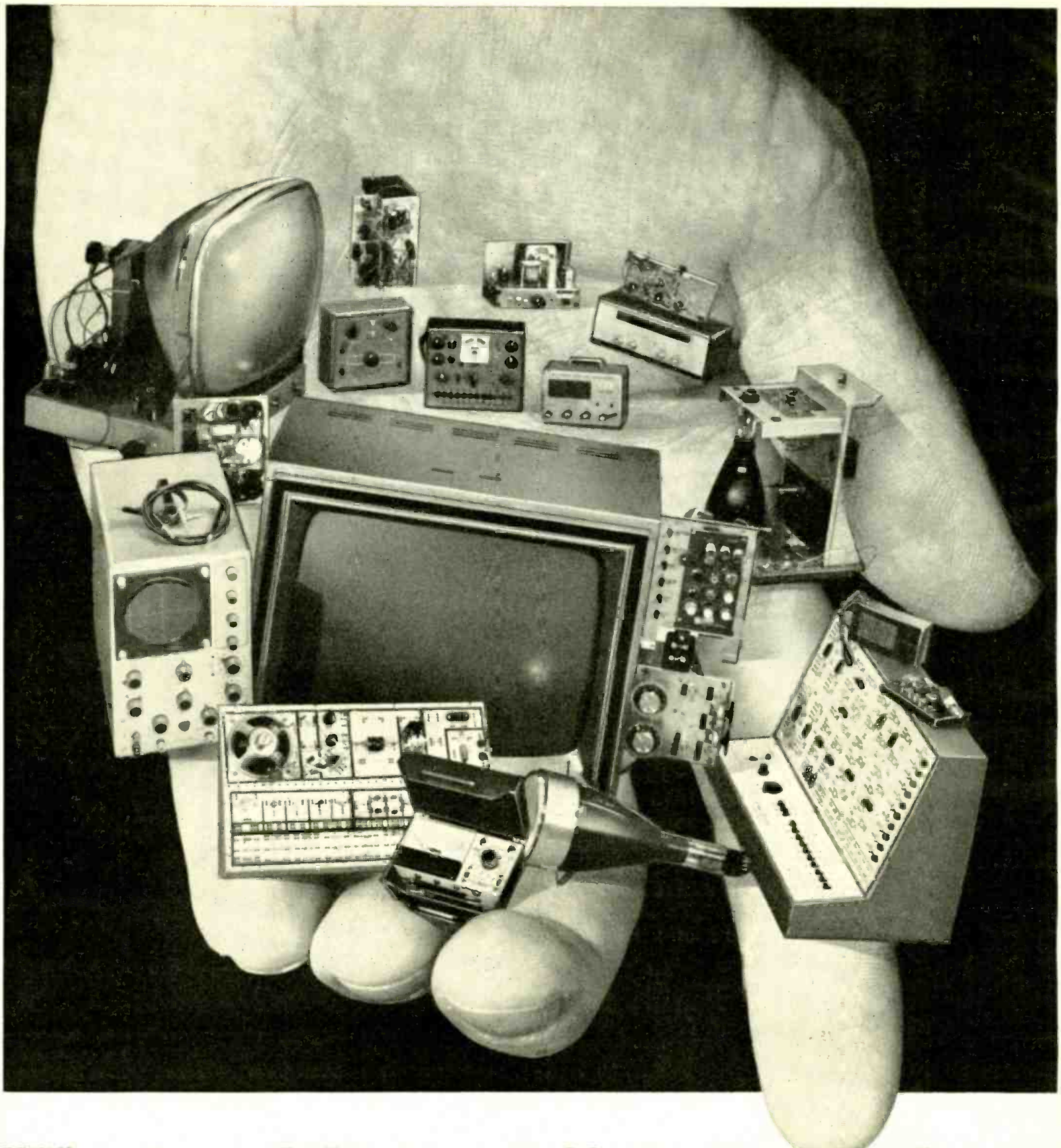
A cartridge in a pear tree.



A gift of the *Shure V-15 Type II* Improved stereo phono cartridge will earn you the eternal endearment of the discriminating audiophile who receives it. What makes the V-15 such a predictable Yuletime success, of course, is its ability to extract the real sound of pipers piping, drummers drumming, rings ringing, et cetera, et cetera. Stereo Review, in a test report that expressed more superlatives than a Christmas dinner, described the performance of the V-15 Type II Improved as ". . . . Unstrained, effortless, and a delight to listen to." All of which means that if you're the giver, you can make a hi-fi enthusiast deliriously happy. (If you'd like to receive it yourself, keep your fingers crossed!) Shure Brothers Inc., 222 Hartrey Avenue, Evanston, Illinois 60204.

SHURE

Circle 16 on reader service card



NTS puts a whole new world at your fingertips.

NTS home training can put a whole new way of life in the palm of your hand. A new, exciting job, a much bigger income is now easily within your reach.

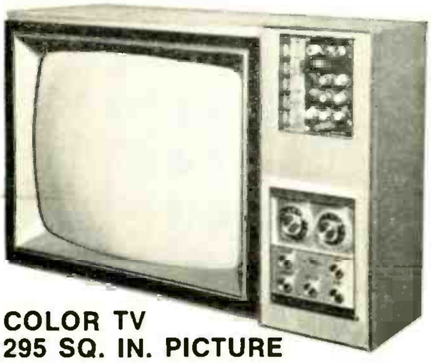
NTS training is something special. We provide all the kits you need for the most effective training. National Technical Schools sends kits with every course, and teaches you to build and test a wide range of professional equipment — the same kind of equipment you'll actually use on the job.

That's the NTS "Project Method" — training that's practical and in-depth. You learn everything from fundamentals to the latest innovations. From beginning to end, NTS makes it fascinating and fun to learn this way. And all you need is a little spare time and an interest in electronics.

Each year, men are moving into important new jobs, or their own businesses, straight out of NTS electronics training. NTS is what's happening to men everywhere. Check the coupon. Take hold of the career you want most. Do it now. No obligation. No salesman will call.

We pack your electronics course with kits to make your training fast. You'll enjoy every minute of it.

NTS COLOR TV SERVICING

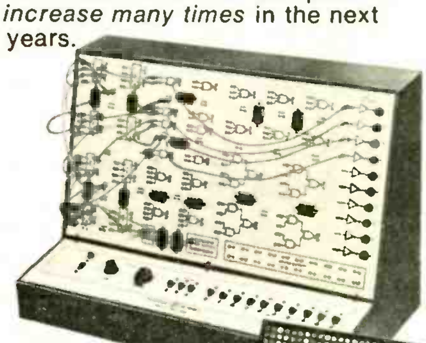


COLOR TV
295 SQ. IN. PICTURE

NTS training provides an easy way to become a professional home-entertainment service technician. You receive a big screen Color TV with many unique features. The unit even includes self servicing equipment that permits you to make all normal test operations. No additional test equipment is needed for adjusting your set. In addition you get an AM-SW radio, Solid-State radio, Field-Effect Transistor Volt-Ohmmeter, and Electronic Tube Tester. You learn about Electronic principles and trouble shooting, hi-fi, multiplex systems, stereo, and color TV servicing.

NTS COMPUTER ELECTRONICS

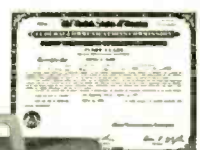
This is the future. And it's happening now. The number of computers will *increase many times* in the next few years. NTS offers a solid grounding in computer operation, wiring, data processing and programming. One of the 10 important kits included is our exclusive Compu-Trainer®. It's a fully operational computer logic trainer — loaded with integrated circuits — the first ever offered in home study. It introduces you quickly to how, what, when and why of computers . . . from theory to practical servicing techniques. This unit is capable of performing 50,000 operations per second.



Exclusive new Compu-Trainer®

NTS ELECTRONICS COMMUNICATIONS

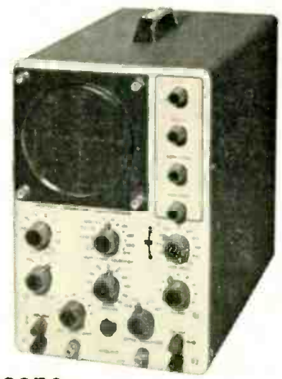
Choose from two exciting courses to get into the big-paying fields of transmitting and receiving equipment: (1) The FCC License Course. (2) The Master Course in Electronic Communications (more comprehensive, with Citizens' Band Two-Way-Radio). Either Communications program qualifies you for your FCC First Class Commercial Radio-Telephone License — *NTS assures you will pass this FCC exam within six months after successfully completing your course or your tuition is refunded.* Kits include an Amateur-Phone 6 Meter VHF Transceiver — NTS exclusive, 6 transistor Solid-State Radio, Volt-Ohmmeter (fully transistorized).



5 Watt AM Transmitter/ Receiver

NTS AUTOMATION/ INDUSTRIAL ELECTRONICS

Let NTS put you into the age of electronic controls. Systems Automation is rapidly becoming the emphasis of modern industry. Your NTS training in automation electronics includes equipment like a 5" wide band Oscilloscope. You also get the new NTS Electronics Lab. It's an exclusive NTS experimental laboratory — a complete workshop that simplifies learning about solid-state, miniature and integrated circuits.



5" Oscilloscope

CLASSROOM TRAINING AT LOS ANGELES

You can take classroom training at Los Angeles in sunny Southern California. NTS occupies a city block with over a million dollars in facilities devoted exclusively to technical training. Check box in coupon.

NATIONAL TECHNICAL SCHOOLS
WORLD-WIDE TRAINING SINCE 1905

4000 South Figueroa Street
Los Angeles, Calif. 90037, U.S.A.

APPROVED FOR VETERANS

Accredited Member: National Association of Trade and Technical Schools; National Home Study Council.

If card is missing check coupon and mail for free color catalog and sample lesson. Now.

National Technical Schools
4000 S. Figueroa St., Los Angeles, Calif. 90037

Please rush Free Color Catalog and Sample Lesson, plus information on course checked below. No obligation. No salesman will call.

- ☐ Master Course in Color TV Servicing
- ☐ Color TV Servicing
- ☐ Master Course in TV & Radio Servicing
- ☐ Practical TV & Radio Servicing
- ☐ Master Course in Electronic Comm.
- ☐ FCC License Course
- ☐ Master Course in Electronics Tech.
- ☐ Industrial and Automation Electronics
- ☐ Computer Electronics
- ☐ Basic Electronics

Name________________ Age_____

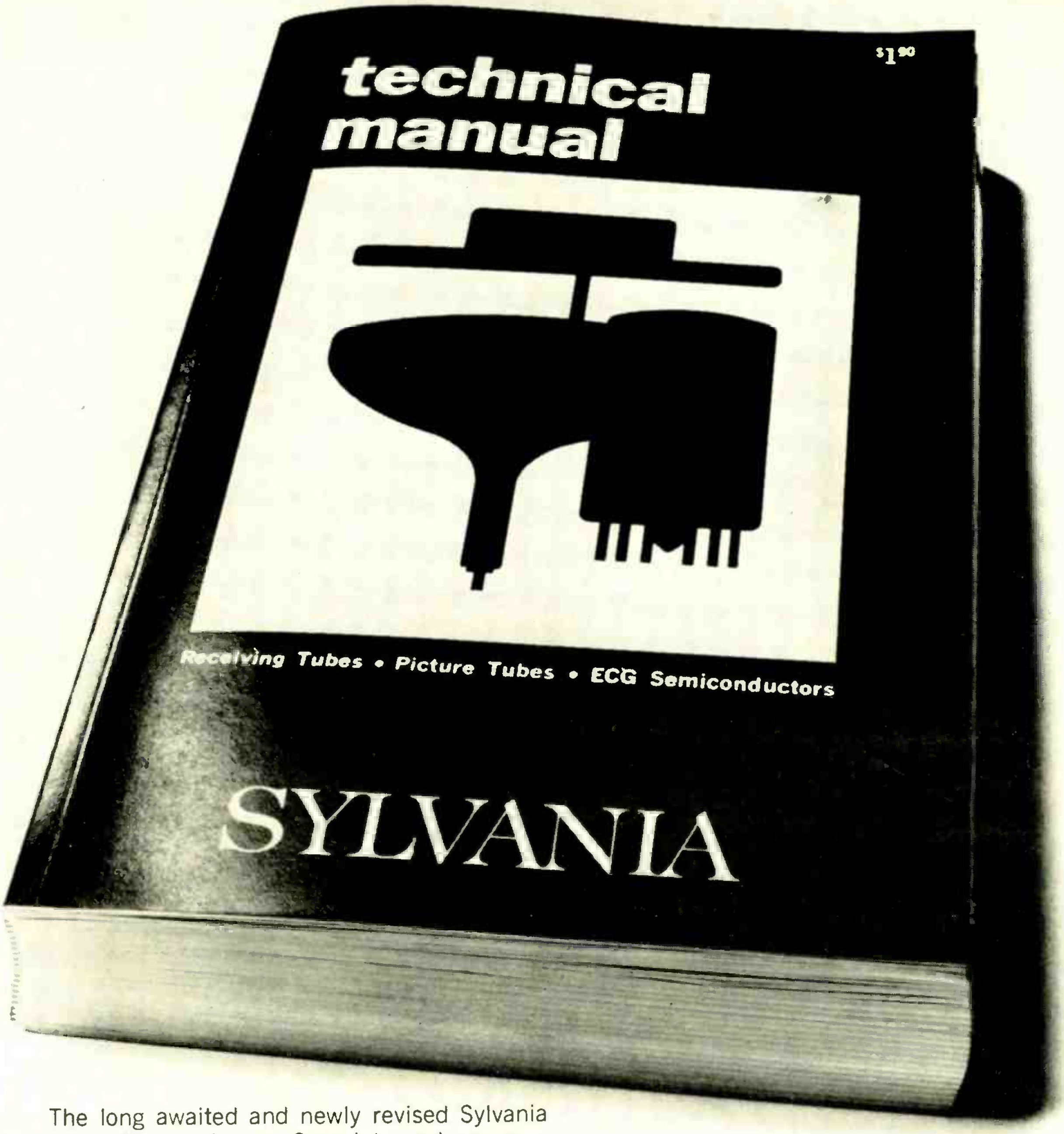
Address______________________

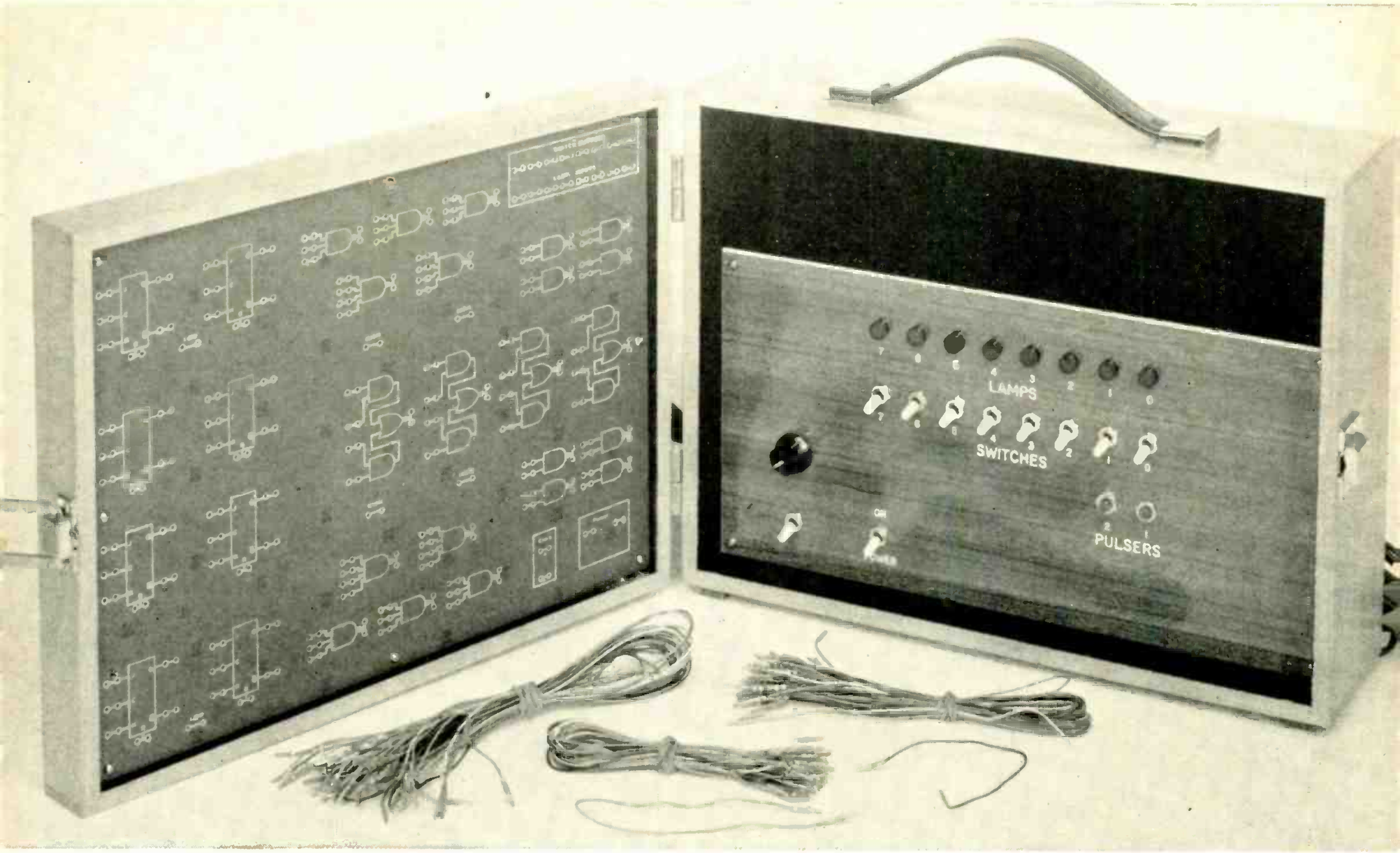
City________ State________ Zip________

☐ Check if interested in Veteran Training under new G.I. Bill

☐ Check if interested only in Classroom Training at Los Angeles

Dept. 206-120


technical
manual
$1.90
Receiving Tubes • Picture Tubes • ECG Semiconductors
SYLVANIA



BREADBOARD A COMPUTER WITH

R-E's Logic Laboratory

by DAVID KORMAN

A number of educational systems have been designed over the last ten years or so that allow a beginner to learn digital logic. Each of these has been expensive, running as much as a thousand dollars or more for a very small system. The system described here costs only a little over $100 yet it is patterned after a system that currently sells for $450.

A computer logic laboratory is a device that can be used to learn about, test and design computer circuits. The unit described here can be used as a home study unit to learn digital logic. It can be used in a classroom to teach digital logic. Having learned logic, the system can be used to construct and test encoders, decoders, gating circuits, counters, shift registers, storage registers, adders, and many other logic circuits.

More than one unit can be "ganged" to build a complete computer. The lab has eight lamps, eight switches, two pulsers, clock circuitry, power supplies and a complete logic system all packed in a 9" x 12" x 4" package for easy portability.

To keep cost low, the entire logic section has been layed out on the reverse side of a printed circuit logic panel. The reverse side contains all interconnect wiring, integrated circuits (Transistor-Transistor Logic), and power distribution.

The front of the card contains MIL806B logic symbols with eyelets used for interconnection. The interconnection is made from gate to gate using wires with taper pins. These make ideal low-cost connectors.

The logic panel is in the 9" x 12" by 1" deep lid of the laboratory. There are provisions for connecting the logic to lamps, switches, pulsers and clock outputs.

The balance of the circuitry, including lamps and switches is in the body of the case. The entire assembly weighs less than 5 pounds making it easily portable. Power for most of the circuitry is obtained from a standard 117-volt outlet. The low drain clock oscillator is operated from a 9-volt battery that should last for a year in normal operation. The battery isolates the clock oscillator from the rest of the circuitry.

Construction details

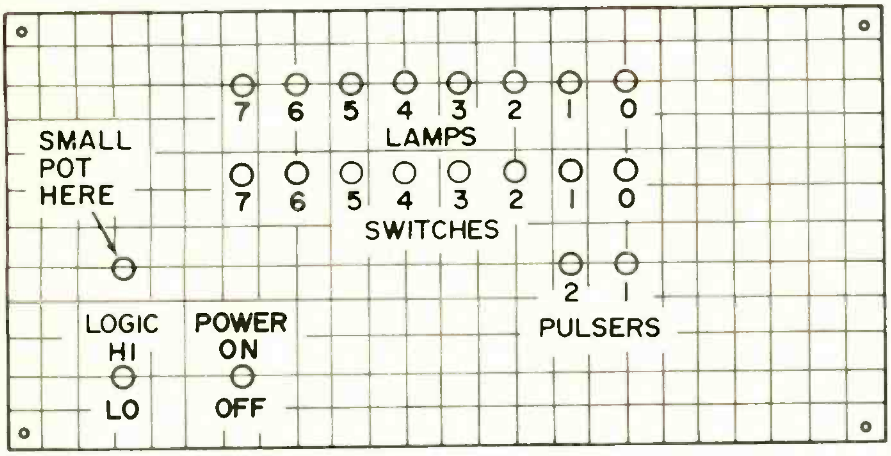
Building the unit is broken down into several individual steps:

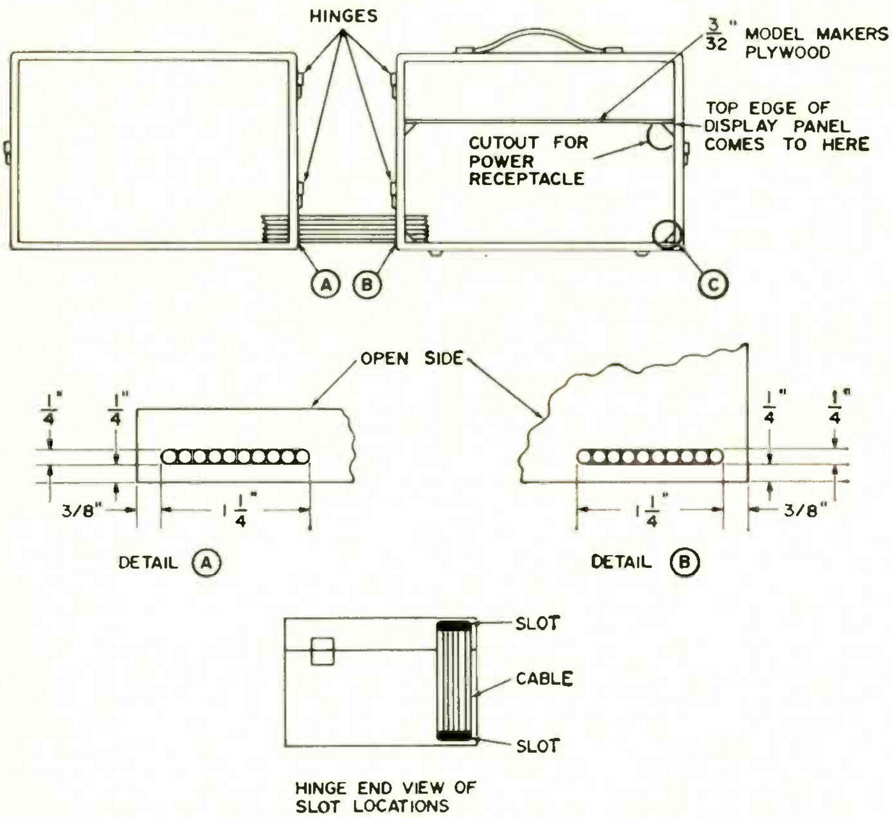
1. Display panel
2. Hardwood case
3. Logic panel
4. Rectifier-regulator card
5. Clock-lamp driver card
6. Final testing and assembly.

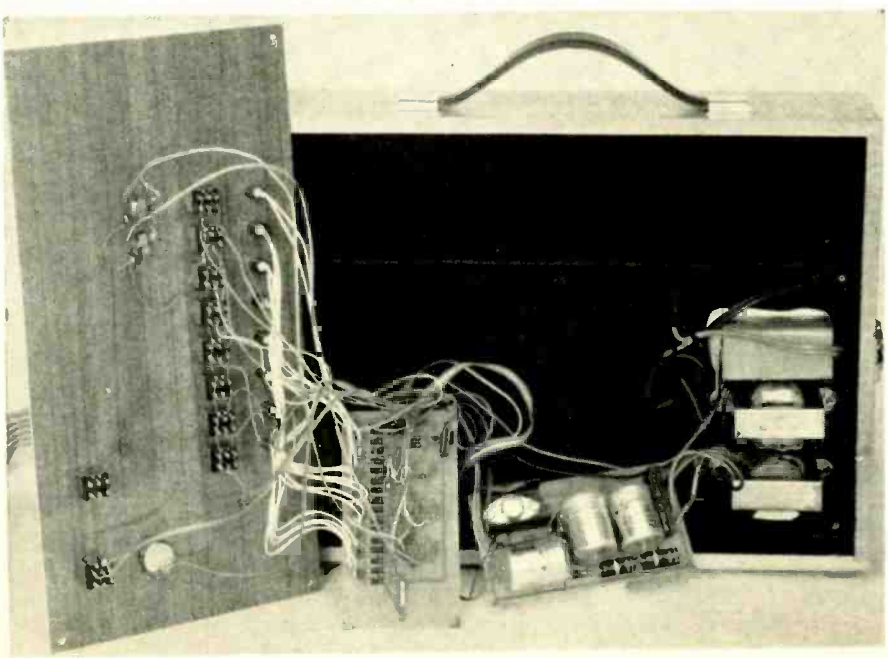
After construction is completed, you will be presented with a complete set of operating instructions and experiments for the laboratory.

Display panel

If you are building your own panel (Fig. 1), make sure all drilling is completed and all legends are in place before starting construction, then ream the lamp holes carefully. **These holes must be just large enough to allow the lens cap to slip in with a fair amount of pressure. The only**







thing holding the lamps in place will be the tension on the lens caps.

After installing all 8 lens caps, install the switches. Remove all of the hardware except the nut nearest the body on all switches. Screw the nut remaining up a couple of turns, put the lock washer in place and fit it into the hole. If the bushing clears far enough to allow the outside nut to screw all the way down without showing any threads, the setting is about right. Mount all switches this way using the two nuts and the lock washer.

Install the two push-button PULSER switches and the small potentiometer. The potentiometer fits in the top left hole in the panel. If necessary, cut the shaft shorter to allow the knob to slide down nearly to the face of the display panel. Install and tighten the knob.

Install the eight lamps by pushing them into the lens caps from the back. Check your work and lay the panel aside for mounting it in the case.

Hardwood case

Check the display panel fit in the deeper part of the case. Mark the point on the case where the top edge of the panel stops. Do this on both sides of the case and using a square, draw a perpendicular line down the inside of the case using the top edge of the case and a tri-square.

Now, at these two points and at the two lower corners, measure 1" and mark the case. Using these marks as guide lines, carefully glue the display panel mounting blocks into place. Check them with the display panel to insure that the display panel touches all four blocks.

Glue in a piece of 3/32" model makers plywood 2 inches wide and 12 inches long to form a box.

Using a 1/4" drill, drill holes as closely spaced as possible as shown in details A, B and the hinge end view of these slot locations. Once drilled, shape the holes neatly with an X-Acto knife.

The next step, though not absolutely essential, will make a far neater job. Remove the hardware and lay it out so that it can be replaced exactly as it was. Sand the exposed edges of the case as smoothly as desired and dope them with ordinary or "hot fuel-

FIG 1 (top)—DISPLAY PANEL is 1/8-in. wood-grained hardboard. Squares are 1/2 in.
(Center)—HOW CASE IS ARRANGED.
(Bottom)—INSIDE THE CASE shows rear of display panel, the power supply and the voltage-regulator and clock/lamp-driver boards. Note transistor on the heat-sink.

proof" model airplane dope. When dry, sand lightly and put on one more coat.

Mask these edges very carefully and spray the interior of both the lid and the case with the color of your choice. I used Krylon flat-black spray lacquer on my unit. Let the glue and paint dry overnight and replace the hardware to complete the case finish.

Mark out the power receptacle cutout from inside the case. Rough it out with a ¼" drill and smooth out the cutout. Drill the holes for the mounting screws and mount the receptacle. This completes the majority of the work on the case.

Lay out the transformers and 9-volt power supply to insure that they will fit properly into the case. Drill holes for mounting all parts that require drilled holes. Use flat washers under the heads of binder head screws on the outside of the case and tighten nuts on the inside to secure all parts in place.

Logic panel

If you do not purchase the card for this section of the logic lab, obtain a piece of 1/16" circuit card material with, preferably, 2-ounce copper on one side. The raw stock should be large enough to accommodate a 9" x 12" card with working room.

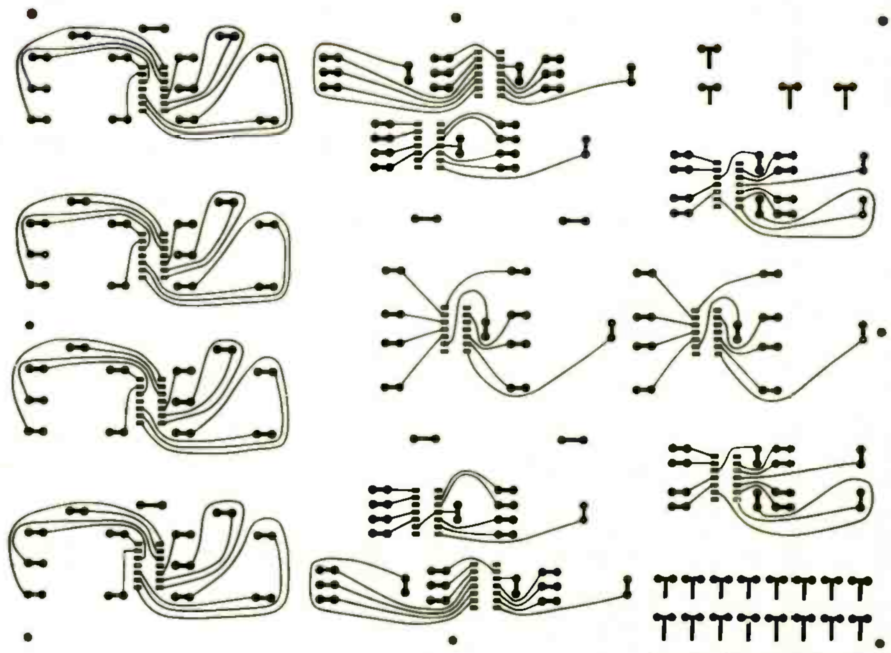
Set up and etch the copper side with the pattern in Fig. 2. Drill the large pad positions with a No. 47 drill. This allows a snug fit for the Mark Eyelet and Stamping eyelets used for terminals. **The small pad positions should not be drilled since the IC's are surface mounted on the pads.**

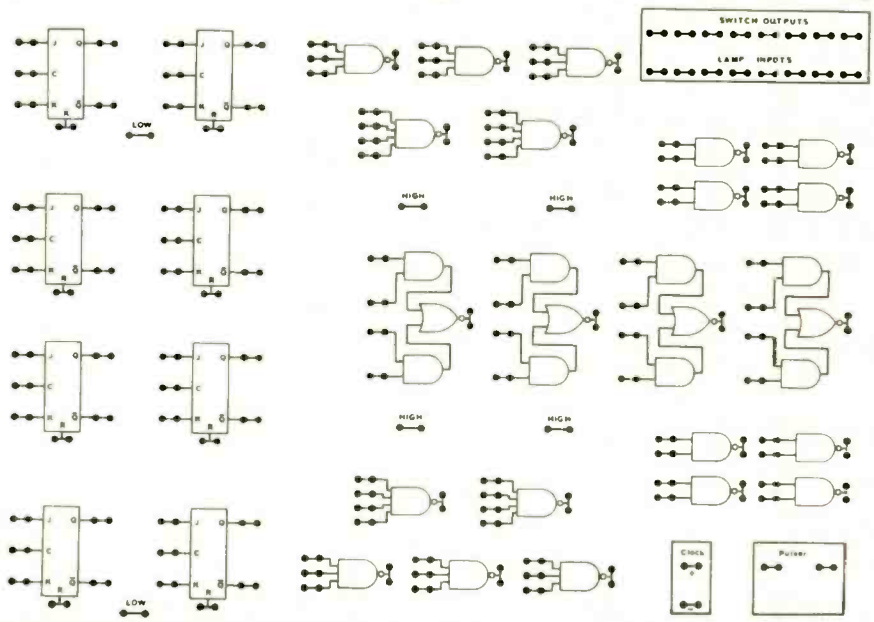
After drilling, insert the eyelets through a film positive or similar artwork of the front of the panel (Fig. 3) cut to match the drilling pattern. Solder the eyelets from the copper side; be very careful not to get solder in the eyelets as these are just large enough to accept the taper pins used as plugs. The eyelets forced through the artwork will hold the artwork in place.

In one instance the pattern for the front panel was etched (using 2-sided copper board) and the resulting conductors cut to avoid causing shorts.

From this point the procedures apply to either a home-brew or purchased circuit-card:

Insert eyelets in each hole press-





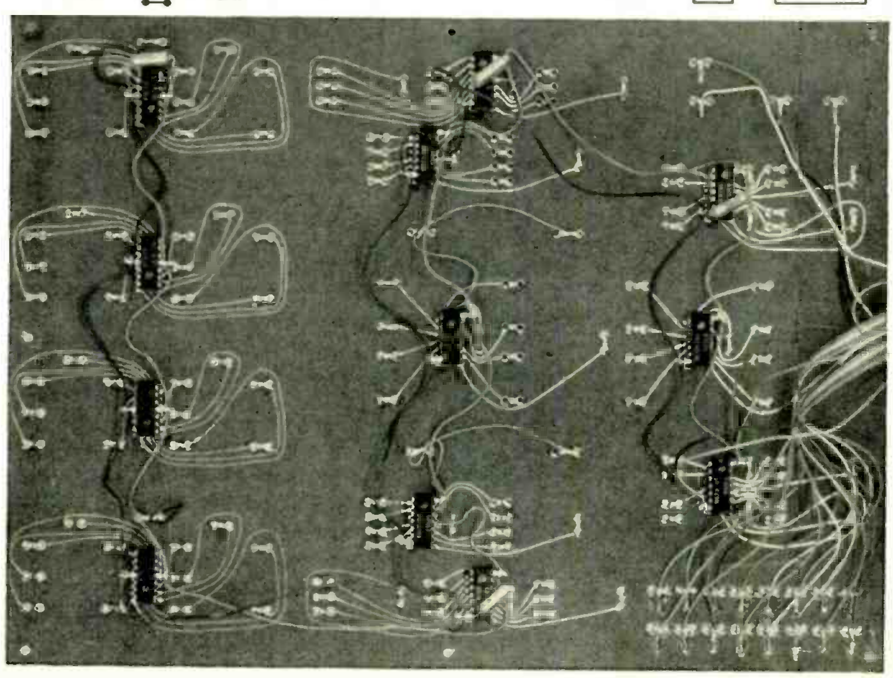
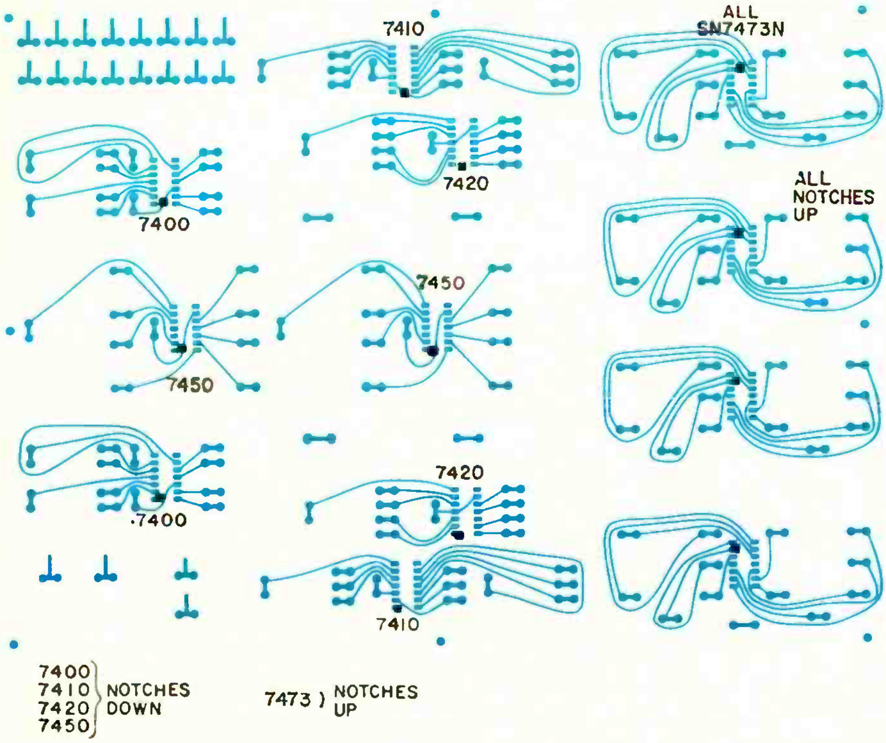
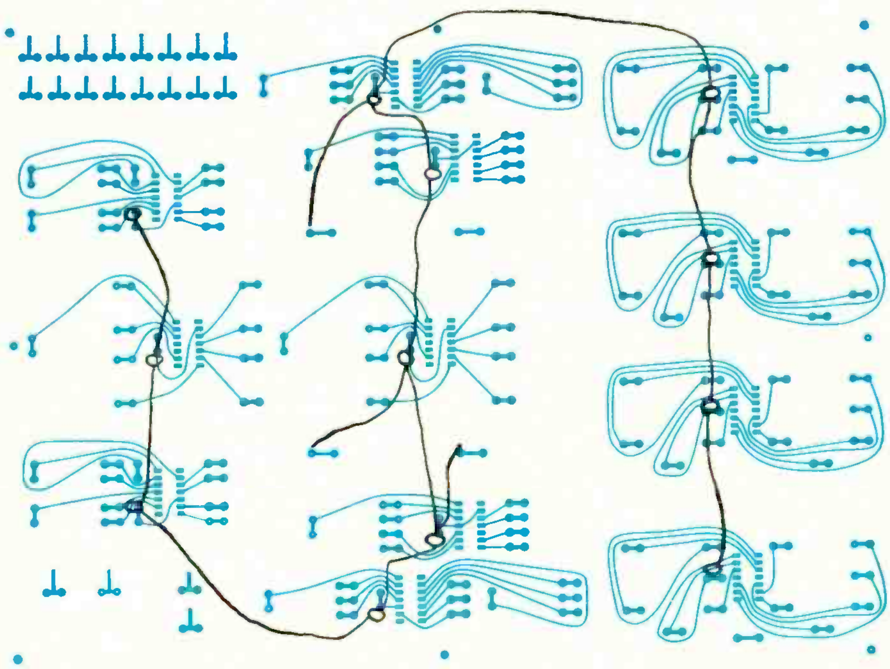
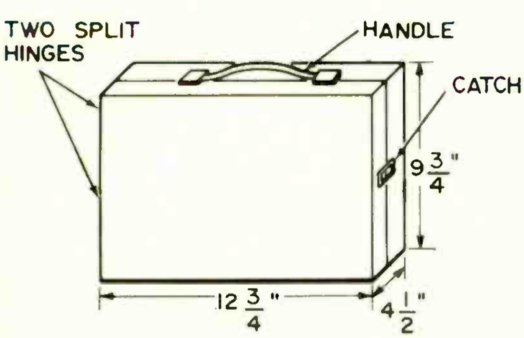


FIG. 2 (top)—LOGIC PANEL WIRING is smaller than half-size. Enlarge so pattern is 11 1/2 x 8 1/2 in. between corner mounting holes. FIG. 3 (center)—FRONT OF LOGIC PANEL. Enlarge to same size as Fig. 2. (Bottom)—LOGIC PANEL PHOTO shows the IC's, all jumpers and leads.







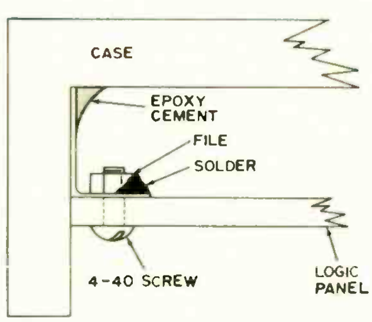


FIG. 4—TYPE AND LOCATION. The 7473's have their notches pointing up; all others point down. **FIG. 5—THE NEXT STEP** is to add the ground leads as shown.

(Bottom)—HOW CASE IS MADE. The top is 1 1/4 in. deep overall and the bottom is 3 1/4 in. Sectional drawing at right shows how the logic panel is mounted on angles.

ing them as near flush with the card as possible. Turn the card over and using a small iron and plenty of care, solder around the outside edge of the eyelet-pad interface. Don't get solder on the inside walls of the eyelet. Should this happen, use a small drill to clean out the inside of the eyelet. Pre-tinning all pads and then using a sweat soldering technique might be the best all-around approach to the problem.

After inspecting the board to insure that all eyelets are mounted and properly soldered, the integrated circuits are mounted as shown in Fig. 4. Their legs can be slightly compressed to make them fit the pattern of small etched holes. Very carefully solder two legs at diagonally opposite corners to the copper pattern. Use as little soldering iron dwell time as possible to avoid lifting the pads. The iron should be as small as possible and as hot as possible. Get on, make sure the solder liquifies and flows and then get off! Inspect the soldering and the positions of the remaining legs to be sure that everything is properly positioned and matched. Solder the remaining legs, excluding the power and ground legs to their pads. Since solder bridges between pads can occur quite easily with the close proximity of these circuit runs and pads, inspect every connection for solder bridges.

Bend the power and ground legs out very carefully to make them parallel to the surface of the card. Use insulated wire to run power and ground connections as in Figs. 5 and 6.

Install five 15-μF, 20-volt tantalum capacitors in the locations shown in Fig. 7.

Attach 8 "L" brackets to the board using 4-40 hardware. File two sides of each nut to remove the plating before tightening it on the screw. One or two of the brackets may have to be shortened to avoid circuitry. After the brackets are installed, fit the assembly into the lid and be sure that the brackets are all properly positioned and fit snugly against the side of the lid. Remove the assembly and solder each nut to its "L" bracket on at least two sides.

Mark the points where the "L" brackets contact the inside surfaces of the lid and apply a generous amount of epoxy cement to each of these locations. Insure that the cement comes no further up the side than the top of the "L" bracket. **Do not apply cement to the "L" brackets as this will smear the case.**

Slide the entire logic panel and bracket assembly back into the lid and allow the epoxy cement to set completely for at least 8 hours at room temperature.

Now, by removing the 8 4-40 screws, the panel can be removed to complete the wiring! The brackets should remain firmly anchored to the walls of the lid with the nuts soldered on the bottom of the brackets.

Rectifier-regulator card

All of the layout and parts placement information required to construct the rectifier-regulator card is on the card artwork or on the card (see Fig. 8).

Mount or install all components except the power transistor as indicated on the card and parts list. Solder and clip all leads close to the board. Inspect all solder connections and insure that all parts are properly placed.

In assembling the power transistor and heat sink, it will be necessary to file the tabs of the top part of the heat sink on both top and bottom to insure good contact between the transistor case and the bottom of the transistor cover and the top of the transistor cover and the screw. Mount and tighten the transistor and transistor cooler assembly.

Be sure to observe polarity of all diodes, rectifiers and electrolytic capacitors. On Zener diode D9 the banded or cathode end should be up (toward the transistor). On Zener diode D10, the band should be toward the MDA rectifiers.

LOGIC LAB PARTS

Parts for the logic laboratory are available from Southwest Technical Products Corp., 219 Rhapsody, San Antonio, Texas. 78216. The following items are available:

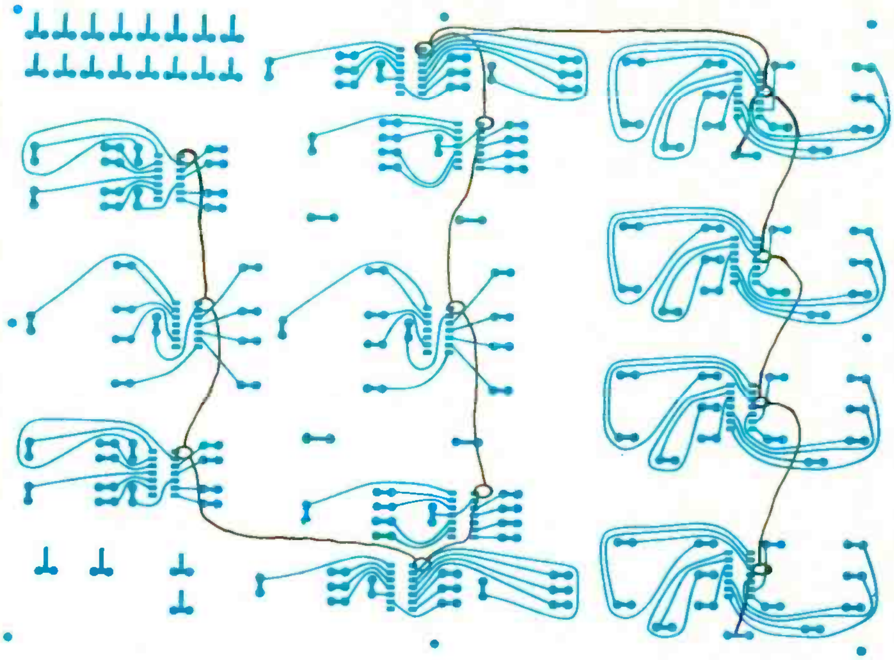
Rectifier-Regulator Board...... $2.20
Kit of parts plus board....... $17.50
Lamp-clock Driver Board...... $2.10
Kit of parts plus board....... $20.75
Lamp and Switch Panel with associated parts........... $20.00
Main Logic Panel Board....... $8.50
Kit of parts plus board....... $36.40

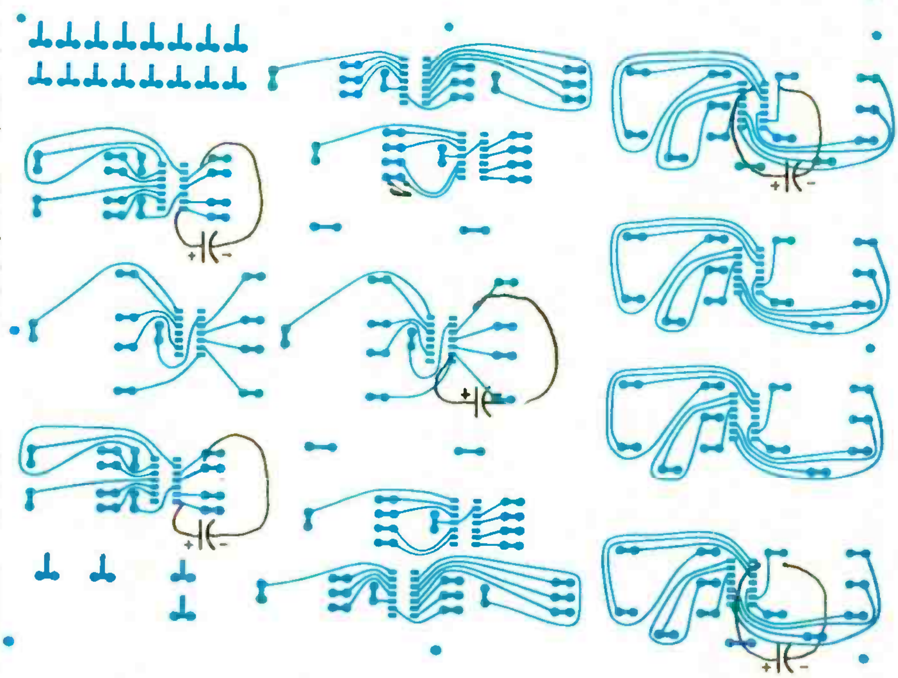
The only parts not listed here are the wood case and the power transformers and filters that go into the case. The pattern for the Clock-Lamp driver board will be printed next month.

The complexity of this article has made it impossible for us to present in a single issue of Radio-Electronics. Next month we will publish the remaining construction details, including full parts lists and sources of circuit boards and parts kits. (Southwest Technical Products).

In February we will start a regular column containing a series of experiments you can conduct with the lab.

(TO BE CONTINUED)





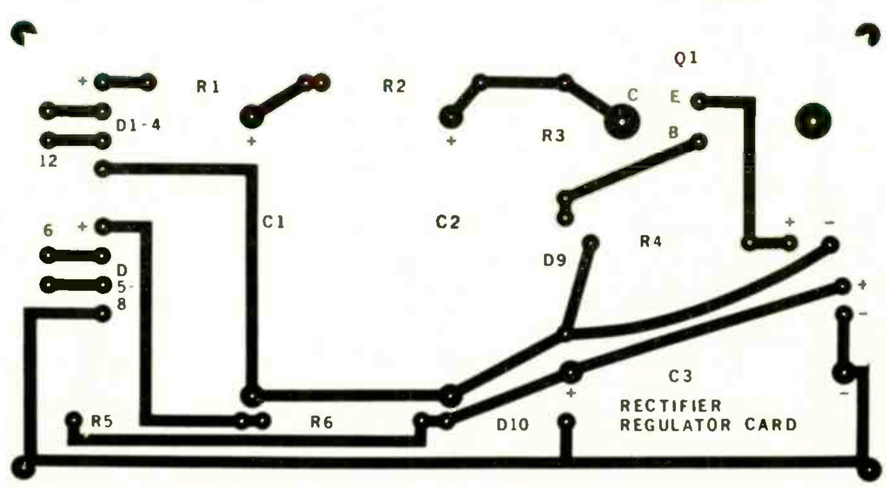


FIG. 6—(top) POWER WIRING on logic panel. Black overlay shows points to be connected with jumper wires. FIG. 7—(center) TANTALUM CAPACITORS are wired into position as shown in the black overprint. FIG. 8—(bottom) RECTIFIER-REGULATOR CIRCUIT BOARD is shown full size. No reduction is needed when using this artwork.

Design for STEREO

how to design your own solid-state audio amplifier

by MANNIE HOROWITZ

Solid-state stereo amplifiers is today's way to go. This new series shows how amplifiers are designed.

This is the first of a series of articles which lead you step-by-step to the design of your own solid-state audio amplifier. Although we assume that you have mastered the basics of electricity, electronics and elementary mathematics, you will find some sections covering elementary topics. These basic facts are included primarily to help you understand some more involved points. We begin by discussing the direction of current flow as it is used throughout this series.

In the heyday of vacuum tubes, it was taken for granted that current flows from the negative terminal of a battery through the load and back to the positive terminal. This is the actual direction in which electrons flow. It is significant only because electrons flow from the heated cathode in the electron tube to the cooler plate.

When talking about semiconductor circuits, it is much easier to use conventional current flow as the standard. Here, current flows from the positive terminal of the power supply, through the load, and back to the negative terminal. This direction is just the reverse of electron flow. The arrow in the symbol of the diodes and transistors indicate the direction of current, not electron flow. It is a great help when describing transistor circuits, to remember that current flow is in the direction of the arrow drawn in the symbol of the particular semiconductor.

With this established, we can now turn to the topic at hand.

FUNDAMENTALS OF SEMICONDUCTOR DEVICES

Semiconductors

Every experimenter is familiar with electrical conductors. Ordinary copper hook-up wire used to connect two components in a piece of electronic equipment, is a common example of a conductor. The chassis used to support the components of an audio amplifier is frequently used as a conductor.

Insulators are just as important in audio work as are the conductors. Air resists the flow of electricity for most useful voltage levels, and is thus an excellent insulator. The plastic, cotton, or enamel covering over the hook-up wire, are important insulators. These are frequently rated by the amount of voltage they can safely withstand before they break down and start conducting. Two good insulators are pure germanium and pure silicon—especially at low temperatures.

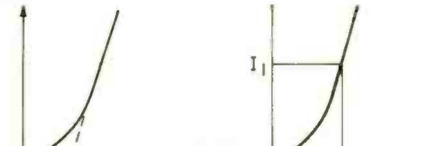


Fig. 1—THE JUNCTION DIODE. Drawing (a) is symbol. When forward biased (b) diode passes current I_D; reverse-biased diode (c) does not normally conduct.

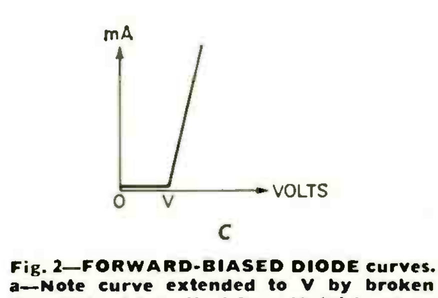


Fig. 2—FORWARD-BIASED DIODE curves. a—Note curve extended to V by broken line. Extend a vertical from V_1 (b) to curve to find current I_1. c—Approximation of diode current above and below V.

Semiconductors are materials that fall somewhere between conductors and insulators in their ability to conduct electricity. Although germanium and silicon, in their pure state, are good insulators, the additions of impurities changes all this. In the impure conditions, they are the basic materials of most semiconductors currently in use.

The characteristics of the semiconductor formed is determined by the impurities added. While one type of impurity will cause an excess of electrons to float around in the semiconductor material, a second type will provide you with a material lacking in electrons and is positive in nature. These materials are assigned names. n-type material contains an excess of electrons while p-type material is lacking in electrons.

An independent piece of n-type or p-type material has little value by itself. Join an n-type semiconductor to a p-type semiconductor, and the practical value of the resulting device is without bounds. This is the geometry of the p-n junction diode. Depending upon the application and specific design, it may be called a silicon rectifier, a Zener diode, a noise diode, a signal diode, a switching diode, as well as by many other designations.

The symbol of the junction diode is shown in Fig. 1-a. The terminal with the arrow is made of p-type material and is referred to as the anode. The end with the straight line is thus the cathode and is made of an n-type slab. Figs. 1-b and 1-c indicate what happens if a battery is connected across the diode. (Do not try this experimentally unless you include a resistor in series with the circuit to limit diode current to safe values.)

A diode will conduct (Fig. 1-b) when the voltage supplied at the anode is positive with respect to that at the cathode. Hence the *p-type material must be positive with respect to the n-type material* if the diode is to conduct. This is an important fact to remember. It is also important to note the direction in which the current will flow. It is indicated by the arrow portion of the diode symbol. It flows from the positive battery terminal, through the diode, to the negative terminal.

In Fig. 1-c, the battery is connected in the reverse direction. Theoretically, no current will flow. The last statement will be modified below to some degree.

Now let us turn our attention to the forward biased diode in the arrangement allowing it to conduct current. There is no intention of implying that all that is required for a diode to conduct is to arrange the supply as shown in Fig. 1-b. However, the voltages must be applied with the polarity shown if the diode is to conduct.

The amount of current a diode conducts depends upon the circuit, upon the applied voltage and upon the characteristics of the particular diode. A typical forward biased diode curve is shown in Fig. 2-a. The solid line indicates how the current the diode passes depends upon the voltage across the diode.

It is simple to determine from the curve just how much current will flow when a specific voltage is across the diode. Just draw a vertical line from the voltage axis (horizontal axis) in Fig. 2-b. This line is to start at a point equalling the voltage, V_1, across the diode. Extend the line until it just touches the solid diode characteristic curve. Now draw a horizontal line from the point where the diode curve and the vertical line just drawn, intersect. Extend this line to the vertical current axis, and note the current reading at the point where this line touches the vertical axis. This current, I_1, flows through the diode when the voltage V_1 is across the diode.

Returning to Fig. 2-a, you will notice that at low voltages, very little or no current flows. As the voltage is increased, the amount of current that flows increases rapidly. This can be looked upon more instructively with the aid of Fig. 3. Here, the diode is in a circuit with a resistor and variable voltage power supply.

Assume that E is increased to very large values. The current that can flow will be limited by the resistor R in the circuit. Regardless of the current flowing, the voltage across the diode will rise very slowly. The bulk of the voltage E will be developed across the load resistor R. The voltage across the diode will increase only somewhat above V in Fig. 2-a.

(Lets stop here for a moment to reflect on just what is happpening. The input voltage E rises rapidly. The current through the circuit increases rapidly. Yet the voltage across the diode remains at about V and rises only slightly above V. A load placed across the diode will have a pretty constant voltage at V despite supply voltage variations. This is the basis of a voltage regulation.)

The point V in Fig. 2-a is quite important. This is basic to the appproximate characteristic curve of the diode. V is determined by assuming that the straight portion of the curve is extended to the zero current axis. The approximate curve is shown in Fig. 2-c. From O volts to V volts, no currrent flows. To a good approximation, it can be assumed that no current flows when the voltage across the diode is less than V. As soon as the voltage across the diode is increased even slightly above V, current will flow and the voltage across the diode will remain at about V volts or rise slightly. The amount of current flowing through the circuit in Fig. 3 willl be relatively independent of the diode, but will depend primarily upon E and R.

Two important numbers should be remembered. For germanium diodes, V is about 0.2 volt. For silicon it is about 0.6 volts. We will use this approximation of the diode throughout the series of articles. It should also be noted that these voltage are relatively accurate at room temperatures, 25°C. They decrease at about 2.5 mV (.0025 volt) for each degree celsius rise in temperature. The effect is to move the entire curve in Fig. 2-a slightly to the left.

The diode is also characterized by its forward resistance. Fig. 4 shows curves representing the forward characteristics of two different diodes. Curve A could be that of a silicon power rectifier while curve B may be the curve of a point-contact germanium signal diode. The dc resistance of the diode is $r_{DC} = V/I$ and is different at different points on each curve. As an example, determine the dc resistance at 0.5 volt for both rectifiers. For power rectifier A, the current flowing is 0.05 ampere and the dc resistance is 0.5 volt/0.05 ampere or 10 ohms. For diode B, the current flowing is 0.1 ampere and the dc resistance is 0.5 volt/0.1 ampere or 5 ohms. In this region, the power rectifier has higher dc resistance than does the signal diode.

Now consider the dc resistance at 1 volt. The current flowing through the signal diode is 0.3 ampere and that flowing through the power rectifier is 1.5 ampere. The dc resistance of the signal diode is then 1 volt/0.3 ampere = 3.333 ohms, and the dc resistance of the power rectifier is 1 volt/1.5 ampere or 0.67 ohms. This is the usual situation that does exist under normal operating conditions—power rectifiers have lower resistance than do point-contact germanium signal diodes. (Note: Point-contact signal diodes have few, if any, audio applications, and will not be discussed here. They are used primarily in rf work. The

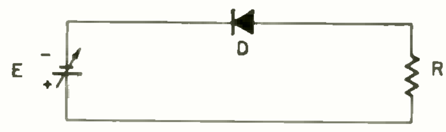


Fig. 3—DIODE IS FORWARD-BIASED by variable voltage source. Resistor R limits diode current to a safe level.

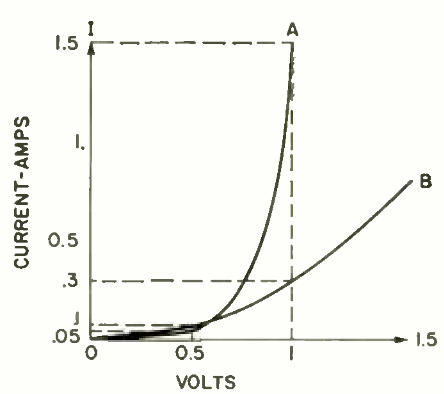


Fig. 4—CURVES FOR TWO DIODES. Curve A represents a silicon power rectifier while B may be a point-contact type.

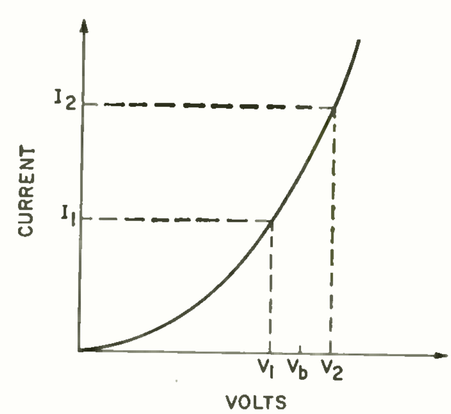


Fig. 5—TO FIND AC RESISTANCE superimpose sinewave ac on dc bias. Subtract V_1 from V_2; divide by I_2 minus I_1.

Fig. 6—EQUIVALENT CIRCUIT of a forward-biased diode. Diode D conducts when applied voltage exceeds battery V.

structure does not consist of a junction of dissimilar semiconductors. It is introduced here only because of the distinct difference of the curve when compared with junction diode curves.) It will also be found that the resistance of junction signal diodes is lower than that of point-contact devices, but is usually larger than that of power rectifiers.

A more important diode characteristic is the ac resistance, r_{AC}. In the discussion above, it was assumed that only direct current flows through the diode. In the more usual case, the current is ac. The ac resistance can be readily and accurately determined from the diode curve. The procedure is described with the help of Fig. 5.

As you know, the ac waveshape is sinusoidal, varying over the 360° cycle. Superimpose this ac voltage on a dc bias (V_0) and apply to the diode. When the ac signal is at a minimum, the voltage across the diode is V_1 while at the maximum, it is V_2. At these instants in the cycle, the current flowing through the diode are I_1 and I_2 respectively. The ac resistance, determined from the slope of the curve, is $(V_2 - V_1)/(I_2 - I_1)$. This is the actual resistance the sine wave sees. The relative ac resistances of the various types of diodes are like the dc resistances in that power rectifiers exhibit the lowest resistances, point-contact diodes have the highest resistances while silicon junction signal devices fall somewhere between the two, but close to the magnitude of the ac resistance of power rectifiers.

A convenient formula to remember for all junction diodes (not point-contact types) is

$$T_{AC} = 26/I_F \qquad \text{Eq. 1}$$

where I_F is the average or dc current flowing through the diode, when this current is expressed in milliamperes (1/1000 of an ampere). I_F is frequently midway between I_1 and I_2. This formula will provide you with ac resistances close in value to those determined from the curves.

The complete equivalent circuit of a forward-biased diode can now be drawn as in Fig. 6. The arrow-line symbol represents the ideal diode showing that current (not electrons) will flow only if the anode (arrow) is positive with respect to the cathode. For the ideal diode, the V of Fig. 2-a is zero. However, V is not forgotten in the equivalent circuit. The battery V represents this cut-in voltage Fig. 2-a. A positive voltage greater than V must be applied at the terminal marked (+) in the equivalent circuit (or at the anode of a real diode), before the diode will conduct. In the equivalent circuit is the ac diode resistance and is drawn as a resistor r_{AC}.

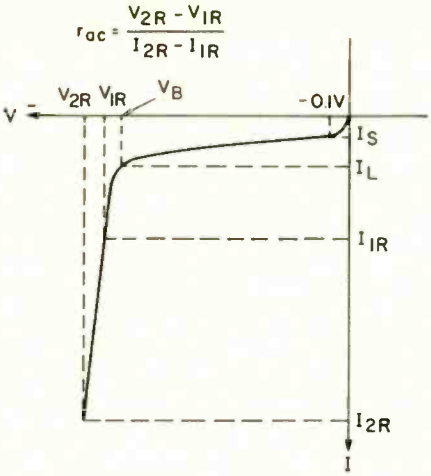


Fig. 7—REVERSE-BIASED DIODE displays this characteristic curve. Current rises very slowly to I_L and then increases sharply as current reaches Zener area.

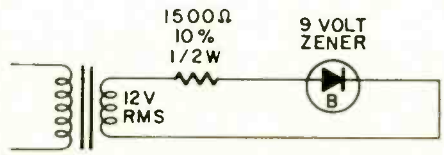


Fig. 8—EXPERIMENTAL SETUP to determine Zener diode characteristics.

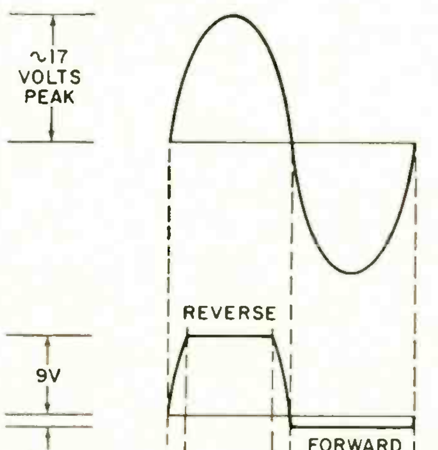


Fig. 9—SCOPE PATTERNS obtained by connecting oscilloscope to test setup in Fig. 8. Top pattern is sinewave across transformer. Middle curve shows the voltage across Zener diode. When reverse-biased, voltage clamps at Zener level and at 0.6 volt with forward bias. Bottom pattern shows current and voltage across resistor. The sum of resistor and Zener voltages equals that across transformer.

Now we turn our attention to the reverse bias characteristic. It is drawn graphically in Fig. 7.

It was stated earlier, with reservations, that current will not flow through the diode when it is reverse biased. Actually, current will flow. When the reverse voltage is about 0.1 volt, a "saturation" current flows (I_S). This current increases only with temperature. It doubles for every 6°C temperature rise when the diode is made of silicon material, while for germanium diodes the saturation current doubles with every 10°C increase in temperature.

As if this is not enough undesirable reserve current, these are impurities associated with the diode which produce a leakage current dependent upon the size of the reverse voltage.

As the reverse voltage is increased, a breakdown voltage is reached, V_B, above which the current increases rapidly. Any slight increase in voltage results in a large increase in the amount of reverse current flowing through the diode. The reverse ac resistance can be determined for this, or for other sections of the curve, using the methods applied to Fig. 5. The sole difference here, is that the arithmetic and construction is now accomplished in the third rather than in the first graphical quadrant. (See the mathematics and construction in Fig. 7.) Note that Equation 1 does not apply here to the reverse characteristic.

An interesting experiment

If you have a scope, a 12-volt ac supply, a 9-volt Zener diode, and a 1500-ohm resistor, you can perform an interesting and instructive experiment.

(First you must understand that the Zener diode is merely a silicon diode with the breakdown voltage, V_B, controlled. In this case, it is equal to 9 volts. The forward characteristics are identical to those of any silicon device. The 1500-ohm resistor limits the diode current to safe values.) Now wire the circuit in Fig. 8.

Place your scope input leads across the 12-volt supply. If the sweep phase on your scope is properly adjusted, you will see a sinewave as at the top of Fig. 9.

Now connect your scope across the Zener diode. The trace will be as the second curve in Fig. 9, approaching the shape of a square wave. Should your scope have a dc vertical amplifier, you will find that the voltage increases sinusoidally above the zero dc level (it is below the zero level if the connections to your scope are reversed) until the 9 volt reverse break-

(continued on page 88)

TV Sound Output (Tube) driven from quadrature sound detector

NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

AUDIBLE SYMPTOMS AS GUIDES		WHERE TO CHECK FIRST		
SYMPTOM PIC	**DESCRIPTION**	**VOLTAGE**	**WAVEFORM**	**PART**
	Sound weak and distorted; turning volume control up may reduce sound			C1 leaky
	Sound completely dead			CE shorted, open R2 slider open R3 open R4 open R6 open T1 open
	Sound slightly weak			C4 open
	Sound distorted, without much change in volume.			R4 high
	Tone control doesn't change sound			C5 open R5 open

NOTES:

Use this guide as a quick way to find which key voltage or waveform to check first.
Study the station sound, as there are no screen symptoms. The clues most helpful for the symptom described are found at the key test points listed.

Use the Voltages Guide and Waveforms Guide to analyze the results of those tests.
For a quick check, test or substitute the parts listed as the most likely cause of the symptom.

THE STAGE

Tube TV chassis nowadays use quadrature sound detectors almost exclusively. The high audio voltage from them is enough to drive power output stages directly. That's why the volume control is in the grid circuit of this sound output stage. Where an extra audio voltage amplifier is necessary, the volume control usually precedes that stage.

This power pentode takes a few volts of input audio signal and builds it into a powerful, high-amplitude audio signal. The intention is to do that without distortion. The tone control in this version is about the simplest imaginable, explained later.

A loudspeaker is a current-activated device. The output transformer converts the high-amplitude output signal into a high-current signal. The voltage across the speaker is much less than across the primary winding of the transformer, a natural result of stepping current up.

SIGNAL BEHAVIOR

The audio signal voltage comes from the plate of the sound detector tube in the chassis used for this example. Coupling capacitor C1 applies the signal across the volume control. Capacitor C2, R1, and C3 form a tone-compensating network that prevents loss of high frequencies as the volume control is turned to low levels.

The slider of volume control R2 determines how much audio voltage from the detector is applied to the grid of V1 through isolating resistor R3. For the audio input

DC VOLTAGES AS GUIDES

change →	to zero	very low	low	slightly-low	slightly high	high
Screen-pin-3 Normal 225V	R6 open C6 shorted		R6 high C6 leaky	R4 low, shorted C4 leaky C4 shorted		R4 open
Plate-pin-6 Normal 210V	T1 open C6 shorted R6 open		R4 low C4 leaky C4 shorted R6 high C6 leaky	C5 leaky C5 shorted		R4 open, high
Cathode-pin-7 Normal 7V	C4 shorted R6 open	R4 low C4 leaky	R4 low R6 high T1 open		C1 leaky	C1 shorted R4 high
Grid-pin-8 Normal 0 V	**C1 leaky **C1 shorted *R4 low *R6 open *C4 leaky *T1 open					
	*Goes negative **Goes positive					

NOTES:
Use this guide and the Waveforms Guide to help you pinpoint the faulty part.
Measure each of the four key voltages with a vtvm.
For each, move across to the column that describes whatever change you find in that voltage.
Notice which parts might cause that change.
Finally, notice which parts are repeated in the combination of changes you find.
Test those parts individually for the fault described.

signal, volume control R2 is the grid load. R3 is also part of the output-transformer secondary load.

The sound signal voltage applied to the grid is amplified tremendously by V1. The signal voltage is made quite high. But the output stage is for *power* amplification. Ample signal *current* must be available, as well as the increased signal *voltage*.

For best power amplification, the output load must match the internal impedance of the tube. The speaker, which ultimately is the output load, has very low impedance; the tube impedance is rather high. The output transformer is designed to match those two impedances. It transforms the high plate impedance of the tube to the low impedance of the speaker. The large-voltage signal is transformed to a low-voltage, high-current signal.

Both cathode and screen of power pentode V1 must be kept at signal ground for efficiency. Capacitors C4 and C6 are electrolytics large enough to completely bypass audio signals at both elements.

Capacitor C7 and R7 form a feedback shaping network. It carries degenerative feedback from the output-transformer secondary to the grid of the tube. Negative feedback reduces distortion. R8 is a constant load for the secondary of T1 in case the speaker is left disconnected. It keeps feedback applied so the stage can't self-oscillate.

The tone network is made up of C5 and R5. The setting of R5 determines how much of the high audio frequencies are shunted to ground through C5.

DC DISTRIBUTION

This pentode stage is cathode-biased; R4 develops the bias voltage, which reaches the grid through R2 and R3.

Plate and screen voltages come from the same 240-volt dc source, and in fact share the same dropping resistor, R6. The dc path to the plate includes the primary of output transformer T1 as well as R6.

Capacitor C1 blocks dc in the sound detector stage from affecting this audio output stage. Capacitor C5 also prevents dc in the plate circuit of this stage being shunted to ground through R5, the tone control.

The comparatively high value of R7 keeps the low dc resistance of R8, or the speaker voice coil, or the secondary winding of T1, from affecting bias applied to the grid.

SIGNAL AND CONTROL BEHAVIOR

Amplitudes of all the signals except the input test signal are affected by the volume control. Amplitudes given are with the control wide open (fully clockwise). The tone-control setting affects the shape of the square-wave, but not its amplitude.

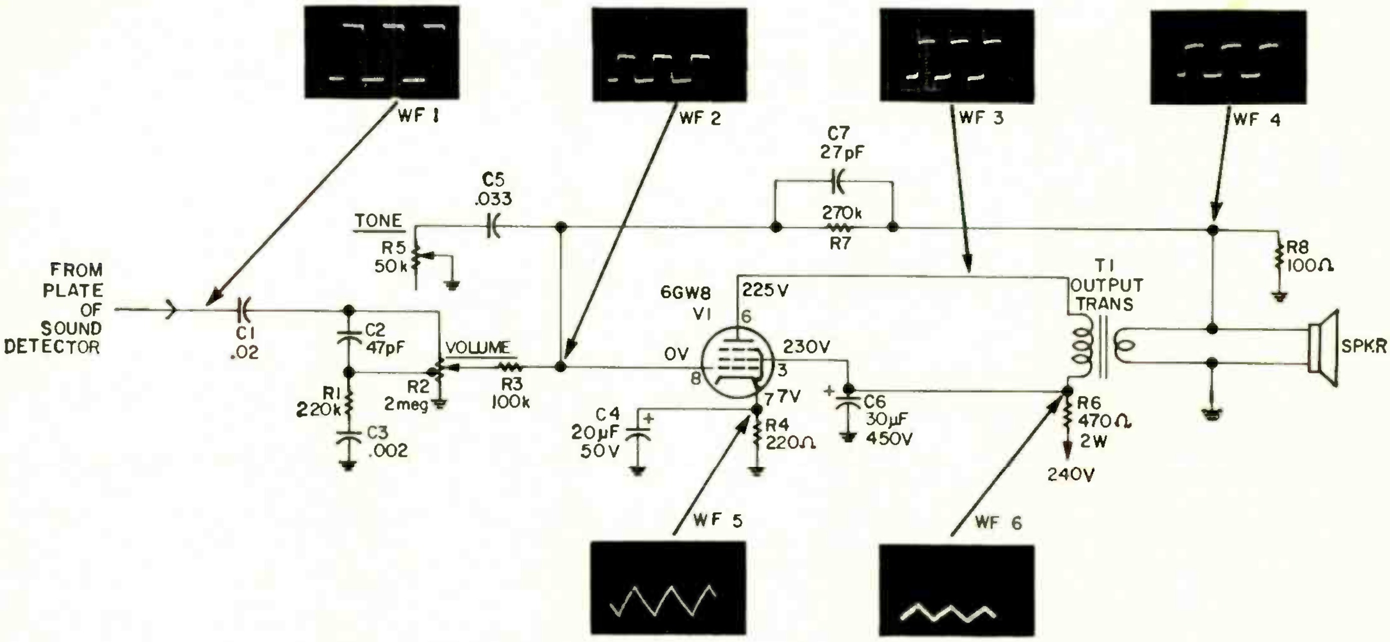
With station signal, the volume control affects signal amplitudes in the stage. If you test with station signal instead of a square wave, the tone control also may seem to affect amplitude of certain kinds of sound signals.

QUICK TROUBLESHOOTING

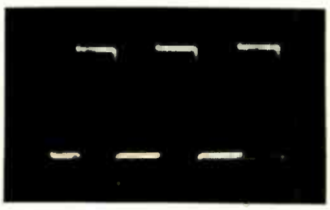
Often, dc voltage tests help you spot quickly the most likely troubles in this stage. But there are other faults that have no effect on dc voltages. Those are the elusive faults that these *Kwik-Fix*™ guide charts are most helpful in finding.

Use a square wave when signal tracing with a scope. It tells you more than a sine wave can. A 1000-Hz square wave is best. It tells you the condition of the amplifier from 100 Hz to 10,000 Hz without your having to run the generator dial up and down.

The waveforms in the chart show the normal effects of the tone control. If you can't obtain both effects by running the tone control up and down, frequency response of the stage has been upset.



WAVEFORMS AS GUIDES



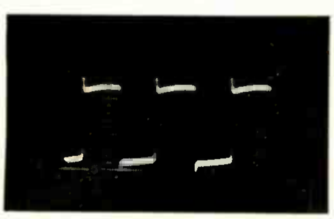
WF1 Normal 10V p-p

Taken at the input point, in this case at the plate of the sound detector. Shown here for reference only. Frequency is 1000 Hz; scope set to show three cycles. Kill the station sound and receiver noise by disabling the sound i.f. stage. Or, you can bias the video i.f. stages off with agc voltage. A square wave at 1000 Hz demonstrates frequency response from 100 Hz to 10,000 Hz. Set the generator output control for this amplitude (10-volts p-p) of signal, so you can tell whether later waveform amplitudes are high or low.

WF2 Normal 5V p-p

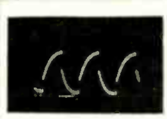
Taken at grid-pin-8. Shows the slight frequency compensating effects of C2–R1–C3 and R3 by a slight slanting of normally flat tops. In some chassis, there is a slight rise at both corners and a vague dip in the middle of the flat tops; this indicates both high- and low-frequency peaking. Amplitude is also down to about half the input value—due partly to the compensating network, partly to R3, and partly to feedback through C7–R7.

V p-p low	V p-p high	V p-p zero C1 open R2 open R3 open					

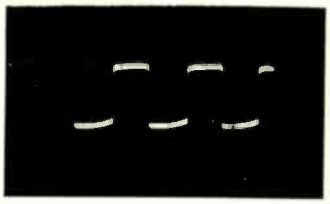


WF3 Normal 240V p-p

Taken at plate-pin-6. This is the signal after being amplified by the power pentode. Slight peaking at high audio frequencies is evidenced by small overshoots at leading corners. Changes in shape caused by turning the tone control up (clockwise) or down (counter-clockwise) are shown in the waveforms below.

V p-p low C4 open R4 high R6 high C6 leaky	V p-p high	V p-p zero C1 open R4 open R6 open R2 open R3 open T1 open	 350V p-p R5(tone)CW	 240V p-p R5(tone)CCW	 350V p-p C5 open R5 open	 360V p-p R7 open	

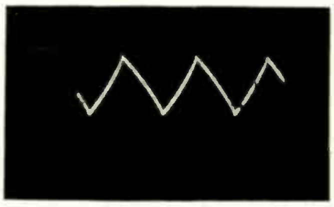
WAVEFORMS AS GUIDES



WF4 Normal 6V p-p

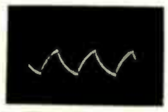
Taken across the speaker terminals. Shape and amplitude change slightly if the speaker is disconnected. Peaking at higher frequencies now is not as pronounced, as you can see from the straighter corners of the square wave. Nor does the tone-control "up" position (clockwise) have as much effect on high frequencies as it does in WF3.

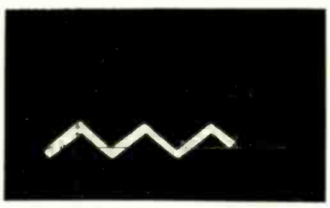
V p-p low	V p-p high	V p-p zero					
C4 open R4 high C6 leaky R6 high		C1 open R4 open R2 open R3 open R6 open T1 open	 9V p-p R5(tone)CW	 6V p-p R5(tone)CCW	 10V p-p R7 open	 35V p-p C7 open	



WF5 Normal 0.6V p-p

Taken at cathode-pin-7. Shown mainly for reference, because this waveform is very small. The big electrolytic capacitor gives it the sawtooth shape. This waveform is most helpful in deciding if the capacitor is doing its bypassing job.

V p-p low	V p-p high	V p-p zero					
R4 high C4 leaky R6 high		R4 open R4 shorted C4 shorted R6 open R2 open R3 open T1 open	 4V p-p C4 open	 0.5V p-p R4 low			



WF6 Normal 3V p-p

Taken at screen-pin-3. This waveform, too, is for reference. It's normally very small, unless the large electrolytic bypass capacitor becomes ineffective. The large capacitance gives the sawtooth shape to whatever small amounts of signal develop across the capacitor.

V p-p low	V p-p high	V p-p zero					
			 15V p-p C6 open				

Use this guide and the Voltages Guide to help pin down fault possibilities.
Inject a 10-volt peak-to-peak (p-p) 1000-Hz, square wave at the plate of the preceding stage.
With the direct probe of the scope, check the six key waveforms.
Set the scope sweep to just above 300 Hz to show three cycles.
Note amplitude. If it's low or high, check the parts listed under those columns.
Note waveshape. If there's a change, check the parts listed under the shape that most closely resembles the change you see.

IC DRIVER FOR FLUORESCENT READOUTS

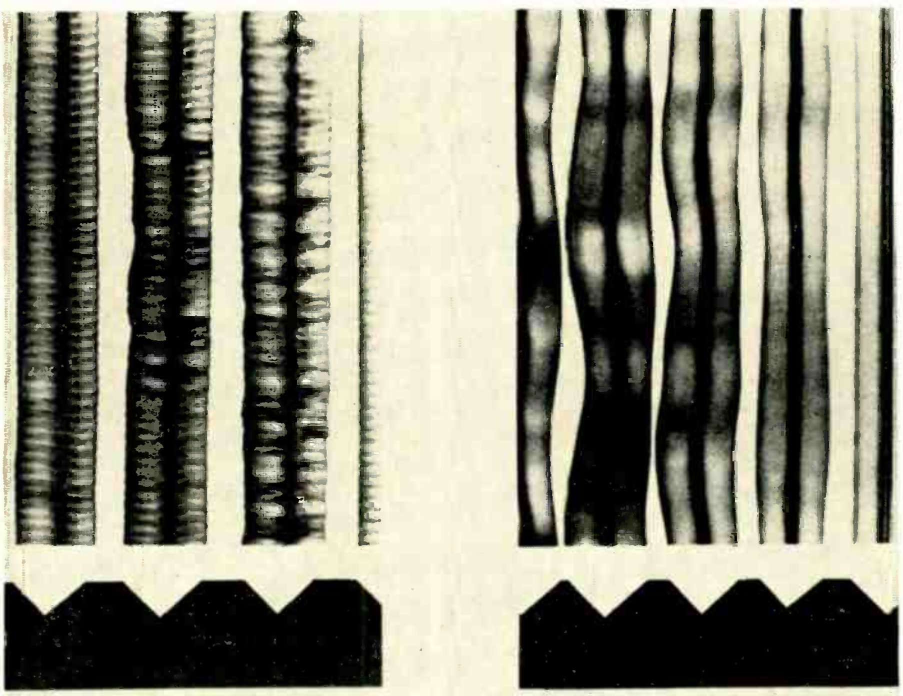
MSI 9327 is the type number of a new bipolar decoder/driver for 7-segment vacuum fluorescent numerical readouts. It is a monolithic IC that accepts four inputs in 8421 binary coded decimal (BCD) format and generates outputs for readout.

The device comes in two models. The 9327A, which has an output breakdown of 64 volts, can multiplex up to 12 readouts and can be used in time-share systems.

Chief application of these units is for driving the Tung Sol Digivac S/G and Sylvania Fluorotron readouts. The units are constructed so that incoming code configurations above binary 9 will disable the outputs to guard against false inputs. A feature of this decoder is an automatic ripple blanking step, which facilitates the reading of displays. The device suppresses all unnecessary zeros, such as those preceding the first significant digit or following the last.

Both versions of these Fairchild devices are available on both 17-pin dual-in-line and flatpack housings, operating temperature ranges of 0°C to +75°C. In lots of 1 to 24, the 9327A DIP and flatpack versions are $14.10 and $15.50, respectively. The 9327B is $11.95 in the DIP and $13.15 in the flatpack. **R-E**

4-CHANNEL STEREO



GROOVES AND CROSS-SECTIONS OF CD-4 SYSTEM RECORD

GROOVES AND CROSS-SECTIONS OF CONVENTIONAL STEREO RECORD

by JOE SHANE

Stereo discs for 4-channel sound are coming. Here's one serious try to establish a standard

A NEW FOUR-CHANNEL PHONOGRAPH record and sound reproducing system puts four tracks of sound into a single record groove. The new system (by the Victor Company of Japan) is compatible with existing records.

Frequency response is 15 to 15,000 Hz per channel. The two "extra" channels are recorded as a modulated carrier in the 20,000 to 45,000-Hz range. A cartridge capable of handling frequencies up to 45,000-Hz is a must. The cartridge output is amplified, then fed through a matrix which separates it into its four channels.

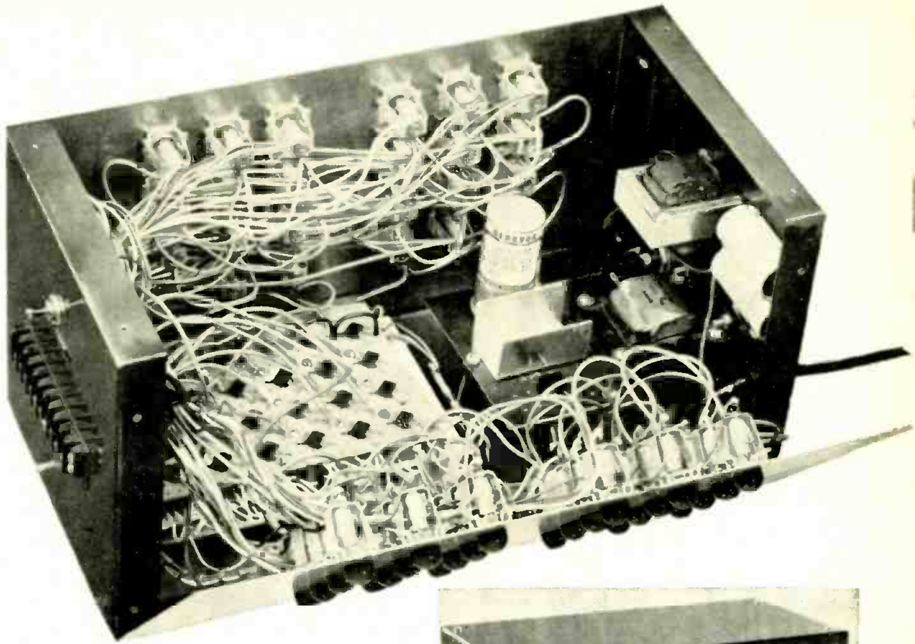
An advantage is that four-channel records can be played on a standard stereo system, while the four-channel system will play 2-channel stereo records.

Owners of quality stereo cartridges need add only the decoder and additional amplifiers to their existing system to play the new records.

There is a catch to this system, however: for it to gain real acceptance the standard would have to be accepted by other equipment manufacturers, and record makers would have to start turning out records to be played on this system. Looking back on how 2-channel stereo went—this may just take a while—possibly a long while. **R-E**

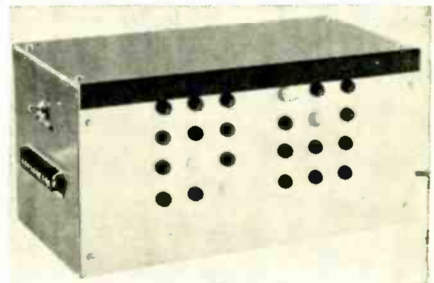
SPECIFICATIONS

Characteristics of the disc	*Characteristics of 4-channel reproducer*
Rpm & Size: same as conventional records	*Pick-up Cartridge:*
Compatibility: compatible with 2-channel stereo records and mono records.	*Frequency Response:* 20 to 45,000 Hz
Frequency Range: Sum—30 to 15,000 Hz Difference—20,000 to 45,000 Hz	*Stylus Type:* elliptical
Cross Talk: Between left and right—25 dB Front to rear—20 dB	*Stylus pressure:* 1.5 grams
Signal to Noise Ratio: better than 50 dB	*4-channel Decoder*
Life: Same as standard stereo disc	*Frequency response:* 30 to 15,000 Hz each channel
	Output: 0.1 volt
	Transistors: 29



Unique timer determines sequence of any four events in games, sports or industry

Build with IC's
ELECTRONIC UMPIRE



by EVERETT L. MILLER

HAVE YOU EVER WATCHED THE PHOTO-finish of a sporting event in which you had more than a passing interest and wondered just how accurate and correct the judge's or referee's decisions were? Or have you ever been involved in an industrial process where split-second decisions must be made as to whether or not the process may safely proceed?

The ELECTRONIC UMPIRE described here was designed to remove the human element from such situations, and to indicate by a system of lamps, in which order the first four of a series of events occurred.

The contest to be judged consisted of two teams of three people each. Each contestant had a push button. At the completion of the quizmaster's question, as the contestant completed writing his answer, he pushed this button which established his place among the six contestants. with four horizontal rows of six lamps each, the lamps in the horizontal rows were numbered to correspond with the six contestants and the four rows were designated first, second, third and fourth place respectively, top to bottom. The first contestant to push this button lit the lamp in the top row which corresponded with his number, thus establishing that he was first. The second contestant to operate his button lit his lamp in the second row, etc.; until the first four places have been determined. The fifth and sixth buttons have no effect in the circuit after the first four have been pushed. Once a button has been used it has no further effect in the game being played and will become operative only after the logic has been reset.

After the first four places have been determined the results are tabulated and the instrument is prepared for another game by opening and reclosing the lamp reset switch and pressing the logic reset button. Approximately 50μsecs are required for the logic to process one signal and shift the remaining buttons to the next row of lamps. Accordingly, the instrument can make 20,000 decisions per second which is adequate for the application.

How it works

Two power supplies are required; one delivering about 4 volts which must be well filtered for the logic section, and a source of dc for the lamps. I used two 6.3-volt filament transformers with full-wave bridge rectifiers. For the 4-volt supply I added a 1000-μF capacitor and a single transistor voltage regulator followed by 3000-μF of filtering. Voltage regulation is not critical as long as we do not get over-voltage surges. For the lamp supply we merely followed the bridge with a 3000-μF filter capacitor which gave 8.5 to 9 volts under no load. The logic supply should be rated 1 ampere as the normal load is about 750 mA. The lamp supply should be rated to handle the size lamps used. We used No. 44 panel lamps and there are a maximum of four lamps on at a time.

Fairchild micrologic IC's were used throughout. IC's 13 and 14 are 900 buffers. IC's 9, 10, 11, & 12 are JK flip-flops 923. All other IC's are 914's. There are 29 modules in all.

Referring to the schematic, with power applied, pushing LOGIC RESET button, S7, applies negative 4 volts to pin 3 of IC14. IC14 was on since connecting pin 1 to positive 4 volts. It now turns off as long as S7 is closed, and it's output is a positive square wave of the same duration. This pulse is applied to pin 5 of IC's 1, 2, 3, 4, 5 and 6. These IC's are connected as flip-flops and the reset pulse conditions them so they are now receptive to signals from player switches S1, S2, S3, S4, S5 and S6.

The reset pulse is also applied to pins 6 of IC's 10, 11 and 12 and through inverter IC8 to pin 5 of IC 9. IC's 9, 10, 11 and 12 are connected as a *shift register* and the reset pulse conditions them such that pin 7 of IC 9 and pin 5 of IC's 10, 11 and 12 are positive. The outputs of these four IC's are inverted by IC's 16 and 17 and applied to one gate of each of twenty-four 2-input AND's, IC's 18 through 29. IC's 18 through 29 are on since one gate of each is tied to positive 4 volts through a 620-ohm resistor. Thus their outputs are at a low level and no SCR's are gated on until this positive voltage is cancelled by a negative signal from IC's 1 through 6.

Assuming player switch S1 is pushed first, flip-flop 1 (IC1) istriggered and pin 7 goes negative while pin 6 goes positive. The negative signal at pin 7 is capacitor coupled to pin 3 of IC18 and this differentiated pulse turns IC18 off momentarily. The positive pulse at the output of IC18 gates SCR1 on, lighting it's lamp. SCR1 stays on, being on dc, until the lamp reset switch S8, is operated at the end of this game. At the same time, the positive output at pin 6 of IC1, which is capacitor coupled to pin 1 of two input OR IC7 is inverted in IC7 and again in IC13. The output of IC13 is inverted by IC15 and fed back into IC13 resulting in an output pulse from IC13 of approximately 50 μsecs.

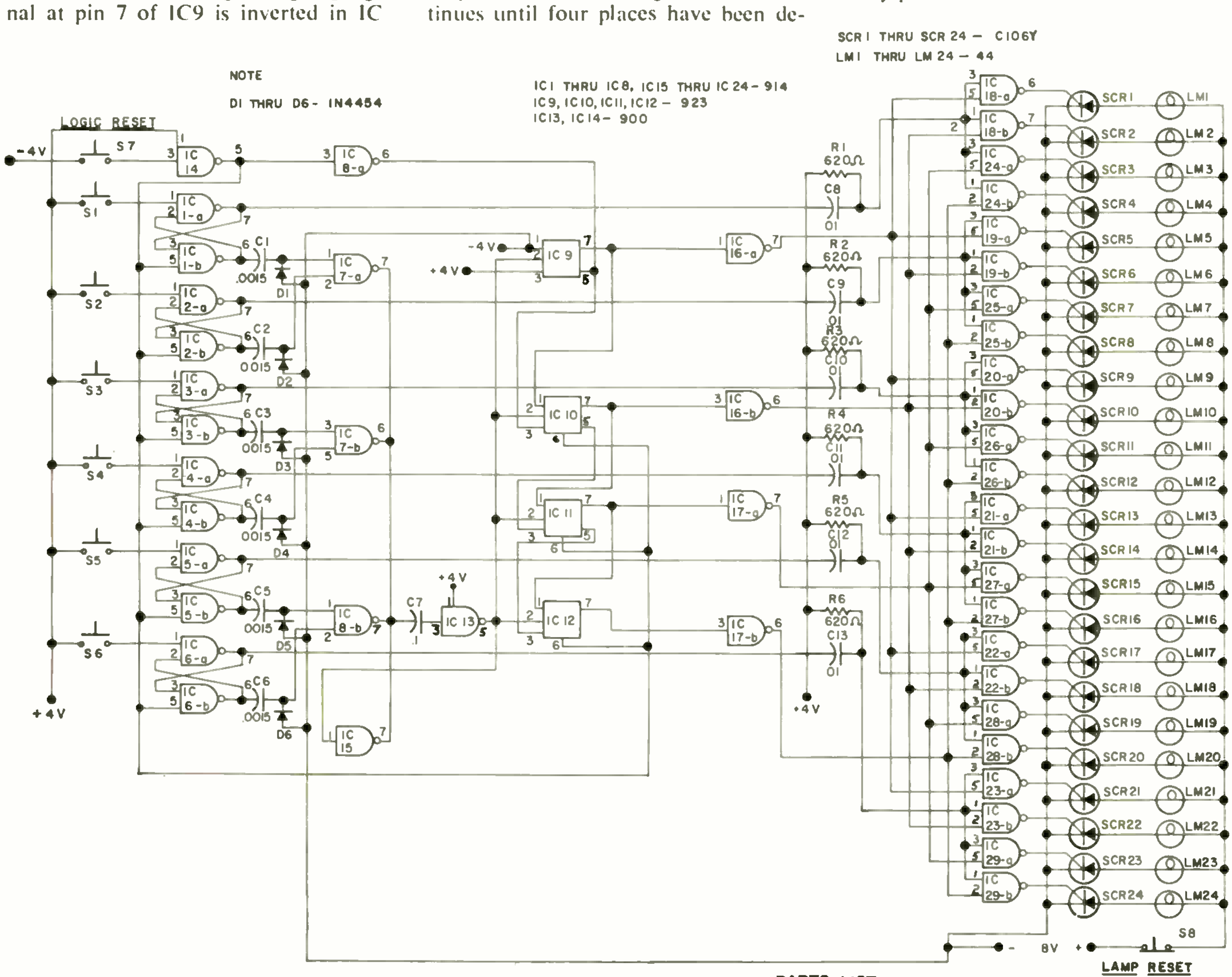
This pulse is a positive square wave and the negative trailing edge of this pulse is used to trigger flip-flop IC's 9 and 10. The negative going signal at pin 7 of IC9 is inverted in IC 16 and applied to pins 5 of two input AND's; IC's 18, 19, 20, 21, 22 and 23. At the same time, pin 5 of IC9 went positive and IC10 was now conditioned the same as IC9 was before S1 was operated. IC10 will now respond to a signal from a second player switch.

From the preceding description, you can see that the first switch a player closes lights his first place lamp which remains lit until the end of the game. Fifty μsecs later the shift register applies a positive bias to one side of all first place, two input AND's, making it impossible to trigger another first place SCR. Also this player, once having triggered his flip-flop, can have no further part in this game, as his switch is no longer effective.

In a similar manner the second player to press his button will light his lamp in the second row and shift his IC's out of service and enable IC11 to process the third signal. This continues until four places have been determined at which time the two remaining switches will have no effect in the circuit.

After the four places are established the results are tabulated, the LAMP RESET is actuated to extinguish the lamps, the LOGIC RESET is pressed and the instrument is ready for another game. The resets should be operated in the order stated as resetting the lamps may generate transients which cause irratic operation of the logic section.

While this UMPIRE was designed for use on games, it also lends itself to many other applications. A switch closure is all that is required to provide an input and it is not difficult to visualize it's application to swim meets, slot car races, etc. Any number of industrial applications exist where an ingredient must be present or an operation occur before the process may proceed. **R-E**



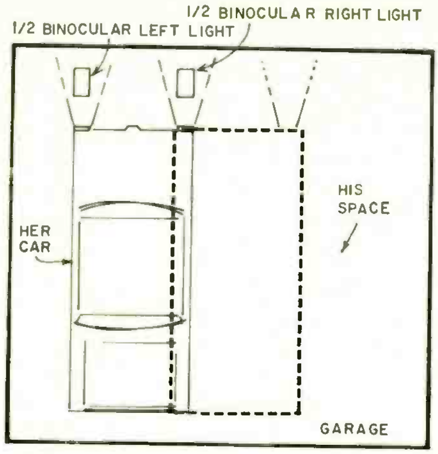
SPLIT-SECOND DECISIONS by electronic umpire are made possible with inexpensive logic IC's in a relatively simple hookup.

PARTS LIST

R1 thru R6—620 ohms, ½-watt, 10%
C1 thru C6—.0015 μF
C7—0.1 μF
C8 thru C13—.01 μF
D1 thru D6—1N4454
LM1 thru LM24—No. 44 panel lamps
S1 thru S7—normally open pushbutton switch, spst, momentary contact
S8—normally closed pushbutton switch, spst, momentary contact
SCR1 thru SCR24—C106Y
IC1 thru IC8, IC15 thru IC24—Fairchild 914 or equivalent
IC9 thru IC12—Fairchild 923 or equivalent
IC13, IC13—Fairchild 900 or equivalent

MILADY'S GARAGE PARKING DIRECTOR

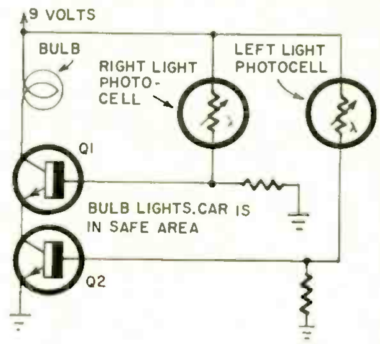
Does your wife have trouble garaging her car so that she leaves enough space for yours while pulling in far enough to permit the door to close? If so, consider the solution to this problem described by Arthur L. Plevy in *Clairex Photocell Forum*. The electronics consists of a transistor AND circuit (see schematic) with base inputs derived from two photocells. The output is a small light bulb that glows when the car is in exactly the



right spot in the garage (see drawing).

The halves of a pair of toy binoculars were separated and used to focus the rays of the car's headlights on the two cells—your wife has to turn on the headlights to use the aiming device. The binoculars are focused so the car has to be close to the rear wall before enough current flows through both cells to turn on Q1 and Q2.

(The author did not specify the components used in the device. I'd start out with npn transistors (preferably germanium) with a I_c max rating of at least 500 mA and a h_{FE} of 20 or higher. A potentiometer would be used between the base of each transistor and ground for sensitivity ad-



justments. The photocells would be a CdS types with a diameter equal to or slightly smaller than the diameter of the lens in the binocular eyepiece. After completing the parking aid, I'd install a lights-on reminder in the car so the headlights wouldn't be left on inadvertently.—*Editor*) **R-E**

CB RADIO CHANNEL 9 EMERGENCY FCC RULES

Latest FCC rules state that the CB frequency 27.065 MHz (channel 9) shall be used solely for:

1. Emergency communications involving the immediate safety of life of individuals or the immediate protection of property or:
2. Communications necessary to render assistance to a motorist.

A licensee, before using channel 9, must determine that his communication is either or both (a) an emergency communication or (b) is necessary to render assistance to a motorist. To be an emergency communication, the message must have some direct relation to the immediate safety of life or immediate protection of property.

If no immediate action is required, it is not an emergency. What may not be an emergency under one set of circumstances may be an emergency under different circumstances.

There are many worthwhile public service communications that do not qualify as emergency communications. In the case of motorist assistance, the message must be necessary to assist a particular motorist and not, except in a valid emergency, motorists in general. If the communications are to be lengthy, the exchange should be shifted to another channel, if feasible, after contact is established.

No nonemergency or nonmotorist assistance communications are permitted on channel 9 even for the limited purpose of calling a licensee monitoring a channel to ask him to switch to another channel. Although channel 9 may be used for marine emergencies, it should not be considered a substitute for the authorized marine distress system. The Coast Guard has stated it will not "participate directly in the Citizens Radio Service by fitting with and/or providing a watch on any Citizens Band Channel. (Coast Guard Commandant Instruction 2302.6.)"

The following are examples of permitted and prohibited types of communications. They are guidelines and are not intended to be all-inclusive.

Permitted	*Example Message*
Yes	"A tornado sighted six miles north of town."
No	"This is observation post No. 10. No tornados sighted."
Yes	"I am out of gas on Interstate 95."
No	"I am out of gas in my driveway."
Yes	"There is a four-car collision at Exit 10 on the Beltway, send police and ambulance."
No	"Traffic is moving smoothly on the Beltway."
Yes	"Base to Unit 1, the Weather Bureau has just issued a thunderstorm warning. Bring the sailboat into port."
No	"Attention all motorists. The Weather Bureau advises that the snow tomorrow will accumulate 4 to 6 inches."
Yes	"There is a fire in the building on the corner of 6th and Main Streets."
No	"This is Halloween patrol unit number 3. Everything is quiet here."

The following priorities should be observed in the use of channel 9:

1. Communications relating to an existing situation dangerous to life or property, i.e., fire, automobile accident.
2. Communications relating to a potentially hazardous situation, i.e., car stalled in a dangerous place, lost child, boat out of gas.
3. Road assistance to a disabled vehicle on the highway or street.
4. Road and street directions. ★

Build

SOLID STATE POWER SUPPLIES

Custom design is the secret that lets you match your need

by MATTHEW MANDL
CONTRIBUTING EDITOR

With so many battery-operated radios, cassette recorders, and record players in use, a power supply saves battery costs when units are played in fixed locations. Also, a power supply is handy on the bench when testing and repairing battery-operated units or when battery charging is needed.

The power supply you need can usually be designed around parts you have on hand. Missing items can be obtained readily and cheaply through parts distributors.

Since most portable units operate from between 6 and 12 volts, filament transformers for tube-type devices make ideal power supply units for the solid-state equipment. The current ratings for such transformers range from 0.6 amp to several amperes which is an adequate power capability for portable devices.

To keep the power supply compact, however, you might want to use the smaller transformers—those without bulky high-voltage secondaries. If size is no factor, the larger transformers can be used, but be sure to tape up the high-voltage secondary winding leads for electrical safety.

Half-wave type

The half-wave type power supply is the simplest, though the rectification is not as efficient as for the full-wave types and filtering must be greater to reduce 60-Hz hum. Since most portable units do not have a frequency response extending down to 60-Hz, the half-wave supply (with large filter capacitors) is usually satisfactory.

A single rectifier is used with an untapped (or unused) secondary winding (see Fig. 1). With a 12-volt transformer, a 25 working-volt rating for the filter capacitors provides an adequate safety margin against filter failure. Larger voltage ratings can, of course, be used if the larger physical size of the capacitor is not important.

For compactness, good front-to-back ratio, and reliability, a silicon rectifier is preferred. Units with voltage ratings of 50 or higher PIV (peak inverse voltage) should be used. If you have some on hand rated at ¼ amp or more, you will have plenty of protection against overload, since few of the more popular portable radios, recorders, or record players draw such high current. If, for instance, a cassette recorder circuit and motor drive draw a total of 100 mA, this is only 0.1 amp, while a ¼ amp rectifier will pass 0.25 amp.

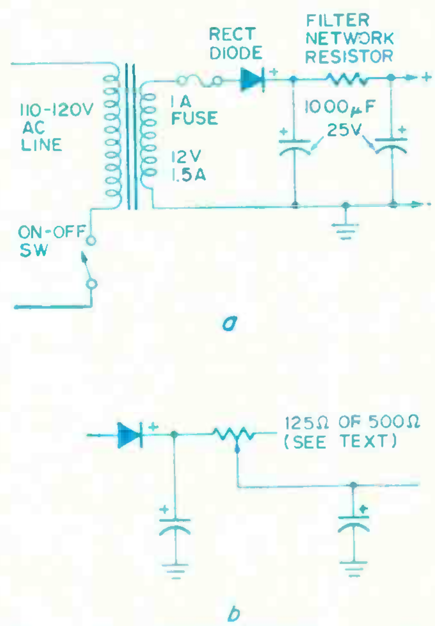


FIG. 1—HALF-WAVE SUPPLY (a). The pot (b) drops voltage to the desired level.

For the supply shown in Fig. 1, an output voltage (under load) up to 12 volts can be obtained, depending on the size of the filter network series resistor. Either a voltmeter or an am-meter can be used to determine the value of the series dropping resistor. With the voltmeter method, a variable resistor is inserted in series with the positive line as shown in Fig. 1-b. Use a 500-ohm pot if the power supply is for low-current devices such as portable radios. If the supply is for units with motors (cassette recorders and record players) use a 125-ohm pot.

Start with maximum resistance and attach the portable unit, making sure your polarities are correct. Place the voltmeter leads across the output and slowly advance the control until the proper voltage appears across the unit. The variable resistor can now be left intact, or the series resistance can be measured and replaced by a fixed resistor. A 1-watt rating will be adequate.

If desired, the current drawn by the portable unit can be measured by placing a milliameter in series with the battery supply (while batteries are fairly fresh). Knowing the output voltage (without load) and the current drawn by the unit, we can use Ohm's law for finding the resistance needed to get the correct output voltage.

Assume a cassette recorder is used, powered by six C cells. That adds up to a 9-volt battery supply. If the current drawn is 100 mA and the power supply output (without load) is 15 volts, we need a 6 volt drop across the resistor when 100 mA flows through it.

By dividing the voltage by the current we find the value of the series resistor:

$$R = \frac{E}{I} = \frac{6}{0.1} = 60 \text{ ohms}$$

The power dissipated by the resistor is: $P = EI = 6 \times 0.1 = 0.6$ watt. Thus, a 1-watt resistor is adequate. After the resistor is inserted into the power supply, recheck the voltage on the unit to make sure it isn't more than required. If operation is satisfactory, but the potential applied to the unit is a volt or so below normal, no resistor changes need be made. For a higher voltage output, however, a smaller resistor should be used.

For a variable supply use a high-wattage rheostat instead, and check voltage output with a load. You can also built a voltmeter into the circuit.

Full-wave supply

A full-wave supply is shown in Fig. 2. It requires two rectifier diodes. Since both halves of the alternating current are rectified the ripple frequency is 120-Hz and filtering for smooth dc is easier. For the power supply shown in Fig. 2 the output ranged up to 6 volts, depending on the series resistor and load. For a 9 to 12-volt output, we need a transformer with 12 volts each side of the center tap (24 volts center tapped).

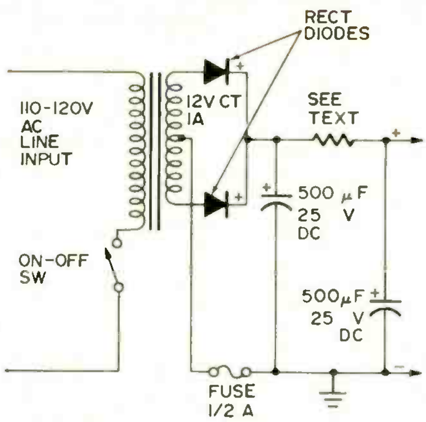


FIG. 2—FULL-WAVE SUPPLY uses two diodes and a center-tapped transformer.

For a 6-volt supply the filter capacitors could have a 15-volt rating, though the 25-volt rating provides an extra safety margin. The value of the series resistor is determined as for the half-wave power supply.

Voltage-doubler type

A 6-volt transformer can be used to supply 9 volts (or more) by using the voltage-doubler circuit shown in Fig. 3. The two series capacitors are charged alternately by their respective diodes to the peak value of 6.3 volts. The output, however, is obtained from across the two capacitors and the sum of the voltages is obtained.

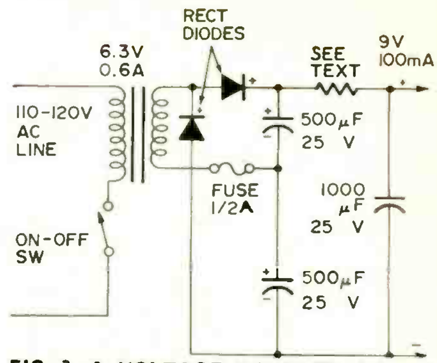


FIG. 3—A VOLTAGE DOUBLER delivers up to 12 volts from a 6-volt transformer.

As with the other power supplies, the output voltage depends on the load current and series resistor. Again, the voltmeter method can be used to find the proper value for the series resistor.

The two series capacitors should have the same capacitance and voltage ratings. Make sure the polarity markings conform to those shown in Fig. 3. Check and be sure the diodes are correctly wired and the circuit fused as shown to prevent damaging the electrolytics and overheating the transformer.

Housing the supply

Power supplies designed to work with portable equipment can be housed in small plastic containers or boxes. Plastic boxes which come with wristwatches also make attractive housings. The size you need depends on the transformer measurements and how well you arrange components before wiring.

The voltage-doubler supply in Fig. 3 was housed in the container shown in Fig. 4. Drill small holes for the ac input line and the output line. Both are anchored in the box with plastic tape. The "on-off" switch

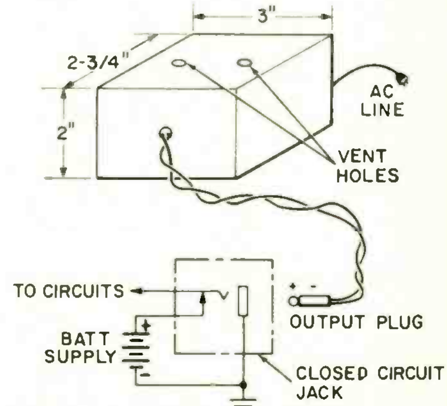


FIG. 4—POWER SUPPLY HOUSING and method of connecting supply to the load.

shown in Fig. 3 was eliminated to save room. With proper fusing and good components, the unit can be left plugged in to the ac line. With the portable radio or cassette player off, virtually no power is consumed.

The output jack used depends on the power-supply input provisions of the radio or recorder. The unit in Fig. 4 was built for a cassette recorder which had a miniature closed-circuit jack as shown. When the plug is inserted the batteries are disengaged.

When the plug is inserted into the jack, there is a momentary short-circuit of the plus and minus sections of the plug as it slides into the jack. It doesn't matter because of the low voltages and currents involved. If, for instance, the resistor in Fig. 3 is 60 ohms, a short across the output of the supply would only draw 200 mA, which is below the rating of the fuse:

$$I = \frac{E}{R} = \frac{12}{60} = 0.2 \text{ amperes}$$

Since very little heat is generated by the power supply during operation, the bent holes can be two ¼ inch holes at the top of the housing.

Voltage regulation

The power supplies described so far have been successfully used with radios and recorders ranging from 100 mW output to 500 mW, with no problems in abnormal voltage variations during operation. Small voltage

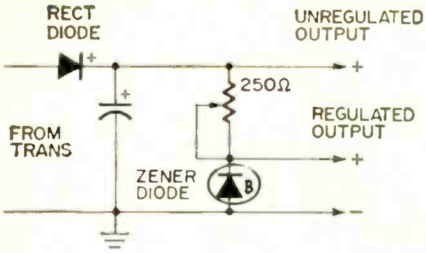
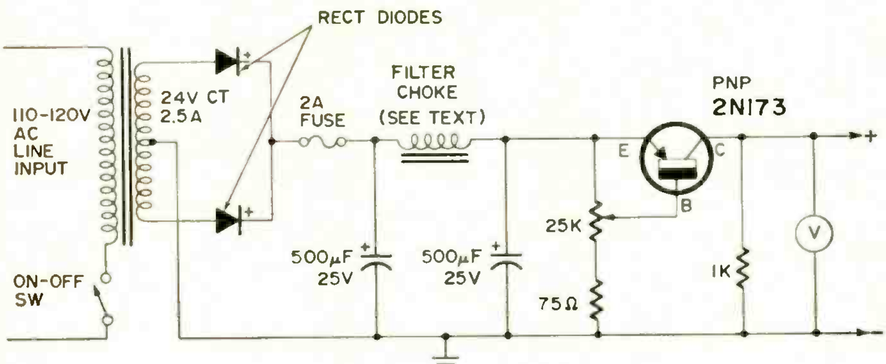


FIG. 5—A ZENER DIODE provides a regulated voltage at a predetermined level.

FIG. 6 (below)—A HIGH-CURRENT supply. Power transistor, as a variable resistor, provides adjustable output voltage.



changes occur because transistors draw more current as rising signal amplitudes increase conduction. If voltage regulation is desired, a Zener diode provides the simplest method.

Zener diodes are available in various voltage and power ratings. The voltage rating indicates the regulated voltage output from the terminal as shown in Fig. 5. The wattage rating relates to the power dissipated in the Zener, and hence to the maximum reverse current at a given voltage (W = EI) that the Zener can pass without internal damage. A 2- to 5-watt rating provides enough of a safety factor for most portable radios, cassette recorders, record players, etc.

The 250-ohm pot in series with the Zener is convenient for adjusting the Zener to operate for a particular load. Start with maximum resistance and measure the output with the radio or recorder attached. Adjust the pot until the proper output voltage is obtained and *maintained* during operation of the load (recorder, radio, etc.).

Make sure the Zener is wired into the circuit as shown in Fig. 5. Note that the Zener has opposite polarity voltages applied across it with respect to the rectifying diode. This reverse voltage is necessary to drive the regulating diode into its Zener region where it will maintain a constant voltage drop.

Bench-type supply

The power supply in Fig. 6 is designed for bench use when testing devices drawing currents up to 2 amperes. The transformer and rectifiers were salvaged from a 12-volt car battery charger. If you use surplus parts from your spare-parts box make sure the rectifiers have a high enough current rating.

For a variable-voltage output, the series resistor is a problem, because a heavy-duty wire-wound pot would be needed. (For a 4-volt drop at 2 amperes, for instance, the pot would have to be rated at 8 watts.) Instead, I use a transistor to provide for smooth voltage adjustment. The 25,000-ohm pot adjusts the bias between emitter and base controlling the current flow between collector and emitter. The 1000-ohm resistor acts as a bleeder and furnishes collector bias in the absence of a load.

The transistor must have an emitter-collector current rating above the amount to be drawn from the supply and a heat sink should be used to avoid transistor overheating. The 2N173 type happened to be one that was on hand, though almost any power transistor will do, such as a 2N2147, or the 2N2869, etc. For different transistor types the value of the base-bias pot may have to be changed for smooth voltage variation.

A filter resistor of even a few ohms will develop too large a voltage drop in low-voltage supplies when higher currents flow through it. (At 3 ohms a 2-ampere flow develops when 6 volts drop across the resistor.) Hence, I recommend using a low-voltage filter choke, with a dc resistance of less than 1 ohm. You can sometimes salvage such a choke from old tube-type car radios.

Chokes are also available from electronic wholesalers. A suitable one is part number 54A2343 from Allied Radio. This choke has a 2-ampere rating, a 0.75-ohm resistance, and an inductance of 0.035 henry. One with a 4-ampere rating is also available from Allied (part number 54A2342) though the higher current rating increases cost.

Battery-charger supplies

The D, C, and other sizes of cells used in portable equipment can be charged a number of times for extended service provided a few precautions are taken:

1. The charging rate should not be too high.
2. The cell should not have been drained too much.
3. The cell should not be very old or have a bulging case.

If, for instance, a 1.5-volt cell has not dropped below 1 volt it can usually be recharged. But if the charging rate is too high the cell may overheat and pressures within the cell will burst the case.

A versatile power supply for battery charging is in Fig. 7. It is useful

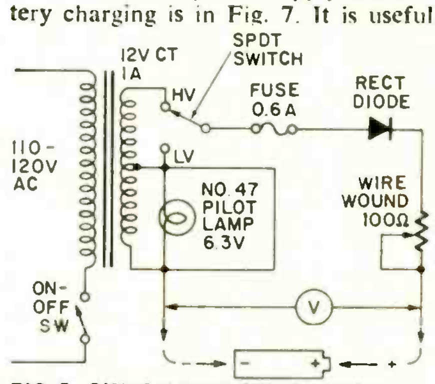


FIG. 7—SIMPLE BATTERY CHARGER has output voltage adjustable up to 9 volts.

for charging cells of 1.5 volts to 9 volts. Several low-voltage cells can be charged either in series or parallel. For battery charging, a simple rectification circuit is fine, and no filtering is needed. A 0.6-ampere fuse provides adequate transformer protection, since even in charging several cells in parallel, currents will not run much higher than 400 mA (0.4 amp).

Use clip leads at the charger output and mount battery holders on a ½" thick plywood base. Several such mounts can be made to accommodate D cells, AA cells, etc. Initially set the pot at maximum resistance and attach the batteries. Check the charger voltage output and advance the variable arm of the pot until the voltage is slightly above that of the batteries. If, for instance, four cells are in parallel and read 1.3 volts, set the charger output slightly below 1.5 volts. As the cells charge they will draw less current and output voltage will rise. Do not permit output voltage to exceed 1.6 or 1.7 volts, to keep the charging rate within bounds.

For a 9-volt battery, switch to the higher charging voltage output. If the battery reads 7-⅓ or 8 volts, set the charger output for slightly less than 9 volts. Don't permit the charging voltage to exceed 9.2 or 9.3. **R-E**

QUART—new three, four channel stereo

QUadrature Ambience

Multichannel broadcast
Here's one approach to

By MICHAEL GERZON*

The advent of 4-channel stereo has raised interest in methods for broadcasting multi-channel stereo via a single FM transmitter. This article describes a novel proposal for multiplexing 3- or 4-channel sound called the QUART (*QU*adrature *A*mbience with *R*eference *T*one) system. The QUART system exists in 3-channel and 4-channel versions, but the basis of both versions is the 3-channel system, and most of the following will be concerned with 3-channels, although the 4-channel QUART system will be described briefly.

The QUART system offers advantages over competing systems. It is compatible with ordinary mono and stereo receivers, and will allow them to be converted to 3- and 4-channel reception at a reasonable cost. One notable feature is that conventional SCA (background music) broadcasts can still be transmitted with both the 3-channel QUART system and with one version of 4-channel QUART system. Despite this, it is possible to transmit and receive all three or four QUART audio channels with a frequency range of about 16 kHz. This is possible because the QUART system "hides" a third channel among the frequencies below 57 kHz taken up by conventional stereo multiplex.

The QUART system is inherently less noisy than *any* 3- or 4-channel multiplex system which uses subcarrier frequencies above 57 kHz, as the third channel in the QUART system is conveyed at the low (and thus relatively noise-free) frequency of 38 kHz. Furthermore, the QUART system does not impose special restrictions on the sound levels that can be conveyed by the rear channels, unlike some systems conveying the rear channels by amplitude or frequency-modulated subcarriers. The QUART system also includes features which allow receivers to automatically adjust themselves to one, two, or multi-channel reception, according to which system is being transmitted.

The following pages describe the QUART system and the various special problems associated with receiver design in general terms. It has not been possible to test the system practically at this time, and some parameters of the system have not been finalized, notably the matrixing used to convey the four audio channels.

How it works

The QUART system, like the NTSC color television system, uses quadrature modulation to convey an additional signal within the usual bandwidth. The QUART signal differs from a conventional Zenith-GE stereophonic signal in that the signal frequency-modulating the radio carrier wave contains an additional suppressed-carrier 38-kHz signal, modulated by the third channel, in quadrature (i.e. 90° out of phase) with the stereo difference signal, and also contains an additonal small constant level 38-kHz signal (called the "reference tone") in phase with the stereo difference signal.

More precisely, let the three sound signals to be transmitted be represented by R (right-hand), (left-hand) and A (ambience, or rear channel). The conventional Zenith-GE stereophonic broadcasting process frequency modulates the radio carrier with the following signal: a monophonic signal consisting of the average of L and R, plus a 19-kHz constant level tone (called the 'pilot tone'), plus a 38-kHz carrier amplitude modulated by the difference between L and R, the 38-kHz carrier being supressed.

The A channel is broadcast in the QUART system by adding to the Zenith-GE modulating signal a second 38-kHz carrier, in quadrature with the carrier modulated by L—R, which is amplitude modulated by A, the carrier being suppressed. To this composite modulating signal is to be added an additional small constant level 38-kHz tone ('reference tone') in phase with the L—R subcarrier. The reference tone is included in the QUART signal to provide radio receivers with means of correcting cross-talk between channels due to phase errors, and also to provide means for automatic switching between three-channel and two-channel operation in the receiver.

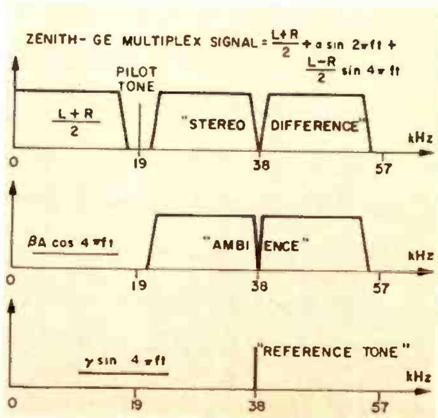
Mathematically, the composite QUART multiplex signal, used to frequency modulate the radio carrier wave, is of the following form:

$$C = \frac{L+R}{2} + \alpha \sin 2\pi ft + \frac{L-R}{2} \sin 4\pi ft + \beta A \cos 4\pi ft + \gamma \sin 4\pi ft \quad \ldots\ldots\ldots (1)$$

where: C = the composite QUART three-channel modulating signal. R, L, and A are the three audio signals equalised according to the conventional 50 or 75 μsec characteristic, t = time (in seconds), f = 19.000 = the frequency of the pilot tone in Hz. α, β, γ are constants which are to be standardised for all broadcasting equipment and receivers. In the following, we consider that version of the QUART system in which α, β & γ are all positive numbers. As in the Zenith-GE stereophonic system, α equals 9% of the peak value of C. Fig. 1 shows the frequency bands occupied by the components of the QUART signal.

Three-channel receiver design

A conventional stereophonic receiver, presented with a QUART signal,



*Mathematical Institute, Oxford, England

with Reference Tone

stereo is coming soon— how it can be done.

will detect the left- and right-hand channels as usual, and will ignore the quadrature ambience signal. Thus a 3-channel receiver will essentially consist of a conventional stereophonic receiver, plus a detector for the "ambience" channel.

In a conventional stereophonic decoder a tuned circuit picks out the 19-kHz pilot tone $a \sin 2\pi ft$, and a frequency doubling circuit converts it to a 38-kHz "switching tone", $\sin 4\pi ft$. This is used to operate a "switching" or "multiplying" circuit that, in effect, multiplies the input of the decoder by $1 + \frac{(4)}{\pi} \sin 4\pi ft$ and by $1 - (\frac{4}{\pi}) \sin 4\pi ft$. The resultant outputs consist of the left and the right hand channels with some cross-talk, which is removed by introducing compensating out-of-phase cross-talk. The left and right channel signals are then de-emphasised.

A basic 3-channel decoder (see Fig. 2) consists of a stereophonic decoder, plus a circuit which shifts the phase of the switching tone by 90° to obtain $\cos 4\pi ft$, plus a circuit that switches or multiplies the decoder input by $\cos 4\pi ft$. [This switching circuit must not pass any of the ½(L+R) signal.]

If a 3-channel receiver is used to pick up a conventional 2-channel broadcast, we want to be able to turn off the

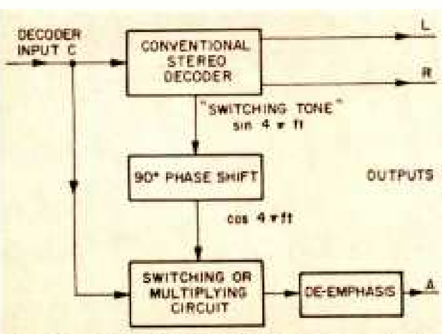


FIG. 1—QUART SYSTEM frequency bands compared to the Zenith-G-E system.
FIG. 2 (above)—How a 3-channel decoder is derived from a standard 2-channel decoder.

third channel, as it will receive nothing but interference and cross-talk. We can use an electronic switch which will short the third channel whenever the output of the (say) L channel has no dc component.

Like stereo receivers, 3-channel receivers must have an i.f. bandwidth wide enough to accommodate the full frequency range (with sidebands) occupied by a QUART FM transmission. This is especially important with three channels, as inadequate i.f. bandwidth will not merely produce distortion, but also a high level of (distorted) cross-talk between the front and rear channels during loud musical passages.

The most serious receiver design problem with the QUART system is that of cross-talk between the 'A' and '½(L−R)' signals, due to filtering before the decoder. Most of the switching circuits used in decoders tend to respond to harmonics of the 38-kHz switching frequency, causing noise signals near, say, 76 kHz or 114 kHz to produce a spurious audio output from the decoder. This results in interference from SCA subcarriers and adjacent-channel interference. There are two ways of avoiding this. The best, but rather expensive, technique is to use genuine low-distortion multiplication circuits fed with pure sine-wave 38-kHz "switching tones". The more usual technique is to use filters to remove frequencies above 57 kHz from the decoder input, and then to use switching circuits in the decoder.

Unfortunately, the irregularities in the amplitude and frequency response below 57 kHz that such filters introduce cause the output of the decoder to contain a good deal of cross-talk between the A channel and the ½(L−R) component of the stereo channels. The amount of cross-talk caused by the pre-decoder filtering will vary with the audio frequency, and will usually be worst at high audio frequencies. There are four ways to deal with this problem:

1. Dispense with the filtering and put up with the extra interference.

2. Use a very elaborate filter which has a substantially flat frequency response and linear phase response up to 53 kHz.

3. Use elaborate frequency-dependent compensating cross-talk networks in the output of the decoder.

4. Compensate for the effects of the filter in the *transmitter* with an elaborate filter in the encoder that introduces exactly the opposite frequency and phase distortions to that introduced by the receiver's pre-decoder filter.

If this fourth proposal is adopted, we must choose a standardised pre-decoder filter which must be included in all 3-channel receivers.

If the 38-kHz switching signals used in the decoder do not have the correct phase, cross-talk between the L, R and A channels will occur. Such phase errors are caused by misalignment of the decoder, or by the multiplex signal being subjected to a poor phase response at some point in the transmission chain. This cross-talk is more serious for QUART tranmissions than for ordinary two-channel stereo.

Decoder with phase-error correction

When the multiplex signal suffers from phase errors, the simple decoder of Fig. 2 will produce output signals with cross-talk. A more sophisticated decoder (see Fig. 3) uses the dc component in the output of the "A" channel to provide automatic correction for phase errors.

The phase-correcting decoder is basically that of Fig. 2. The stereo decoder in it is conventional, except that it contains a "variable phase shift" circuit that can shift the phase *either* of the pilot tone before it is frequency doubled, *or else* of the frequency-doubled "switching tone". The amount of phase shift produced by the variable phase shift circuit depends on the amount of dc bias applied to it. The object of having such a phase shift circuit is to enable matching the phase of the switch-

(continued on page 58)

Better than 9 out of 10 CIE men win their "ticket" the very first time they try

(NATIONAL AVERAGE IS ONLY 1 OUT OF 3)

Cleveland Institute of Electronics

WARRANTY

of success in obtaining a Government FCC License

The Cleveland Institute of Electronics hereby warrants that upon completion of the Electronics Technology, Broadcast Engineering, or First-Class FCC License course, you will be able to pass the FCC examination for a First Class Commercial Radio Telephone License (with Radar Endorsement);

OR upon completion of the Electronic Communications course you will be able to pass the FCC examination for a Second Class Commercial Radio Telephone License;

AND in the event that you are unable to pass the FCC test for the course you select, on the very first try, you will receive a FULL REFUND of all tuition payments.

This warranty is valid for the entire period of the completion time allowed for the course selected.

G. O. Allen

QUART
(continued from page 53)

ing tone with the phase of the reference tone. The dc bias on the phase shift circuit is obtained by passing the "A" output of the decoder through a low pass filter (to remove audio-frequency components), and amplifying it. The polarity of this dc bias must be set to *decrease* phase error!

The phase error correcting decoder should not be required for normal reception, and its main use is likely to be in long transmission links conveying multiplex signals between transmitters.

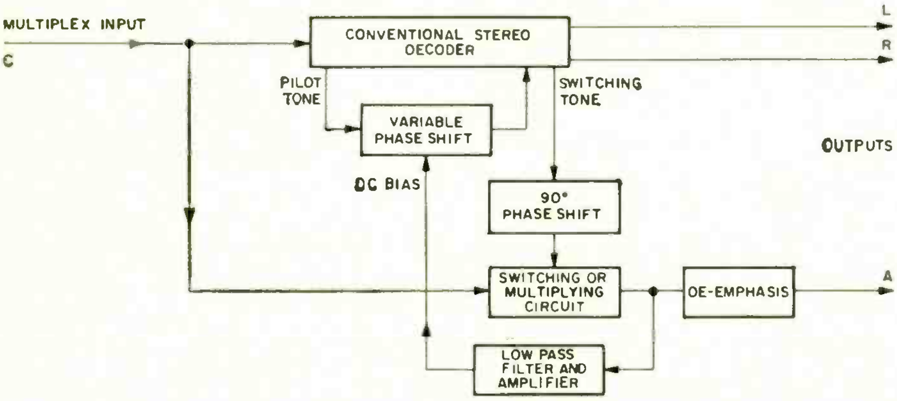


FIG. 3—A 3-CHANNEL QUART SYSTEM that incorporates automatic phase correction.

Note that the phase error correcting decoder will give incorrect results if the polarity of the multiplex signal is incorrect. However, the polarity of the dc signal on the stereo channels provides an automatic indication of whether the multiplex signal has the correct polarity.

Any competent engineer should be able to design encoding circuitry to produce a signal of the form given in formula (1). But there are a few points which require special attention. The encoder must be designed so that the stereo difference 38-kHz modulation is accurately in phase with the 38-kHz reference tone, which signals should both be accurately in quadrature with the 38-kHz ambience modulation. The phase errors of the 38-kHz signals should not exceed 1° at the encoder. In some encoder designs, the 38-kHz reference tone is obtained by adding a dc component to the stereo difference signal modulating the 38-kHz subcarrier. It is desirable to filter out frequencies below 20 Hz from the ambience signal fed into the encoder; otherwise low frequencies in the ambience signal might contribute to the dc bias in the decoder of Fig. 3, causing spurious cross-talk in the receiver. (The low-pass filter in Fig. 3 cannot be designed to have a sharp cut-off without introducing instability in the feedback loop). Be careful not to introduce any filtering of the encoded QUART signal that would tend to cause cross-talk in the output of a QUART receiver. It should be checked that the encoded QUART signal has the correct polarity.

Imperfect reception conditions

Recent calculations indicate that significant phase errors cannot occur under the usual conditions of mild multipath reception, contrary to my initial expectations. Under conditions of severe multipath reception, the cross-talk caused by phase errors will be highly distorted, and this distortion will not be removable by the phase-error correction technique described earlier. For this reason, the simple (and cheaper!) decoder will always prove adequate for receiving a QUART signal. It is, of course, still necessary to adjust the phase of the switching signals accurately in the decoder. The reference tone is still useful for automatic 2-channel/3-channel mode switching, and for checking the accuracy of the phase of the switching signal in the decoder.

The noise performance of the QUART system is necessarily worse than that of the Zenith-GE system. Assuming that $\gamma = 5\%$ and that all three channels must carry signals of equal audio energy, the volume of sound received by a mono or stereo receiver tuned to a QUART broadcast is 2.3 dB lower than when tuned to a Zenith-GE broadcast: the signal-to-noise ratio obtained by a 3-channel receiver tuned to a QUART broadcast is 3.5 dB worse than that obtained by a stereo receiver tuned to a Zenith-GE broadcast under similar conditions. If it is assumed that the rear channel need only carry signals of half the audio energy of the signals conveyed by each of the front channels, then these two figures become 1.5 dB and 3.5 dB respectively.

Four-channel transmissions

To prevent wastage of the available frequency deviation, it is necessary to convey a fourth channel by a suppressed-carrier amplitude modulation above 57 kHz. To recover the suppressed subcarrier, the fourth channel modulation must be at 76 kHz or 95 kHz. From the viewpoint of noise, simplicity of receiver design, and required i.f. bandwidth, the choice of 76 kHz is best. The main advantage of using 95 kHz is that SCA transmissions will still be possible.

The following two forms of the QUART system are proposed for 4-channel broadcasting:

QUART II using a 76-kHz subcarrier, with multiplex signal of the form:

$$C = \tfrac{1}{2}(L+R) + a.\sin 2\pi ft + [\tfrac{1}{2}(L-R) + \gamma]\sin 4\pi ft + \tfrac{1}{2}(U+V)\cos 4\pi ft + \frac{U-V}{\sqrt{2}}\sin 8\pi ft$$

QUART III: using a 95-kHz subcarrier, with a multiplex signal of the form: $C = \tfrac{1}{2}(L+R) + a.\sin 2\pi ft + [\tfrac{1}{2}(L-R) + \gamma]\sin 4\pi ft + \tfrac{1}{2}(U+V)\cos 4\pi ft + \frac{U-V}{\sqrt{2}}\sin 8\pi ft$, where [illegible]bols are as in formula (1), except U and V, which are the rear left and right hand channel signals respectively, with amplitude and polarity given by the convention used for R, L & A above.

A sum-and-difference technique is used for the rear channels in QUART II and III to prevent one rear channel having an excessive noise level, and so that under noisy conditions of reception the listener has the option of switching off the rear difference signal $\frac{U-V}{\sqrt{2}}$ so as to improve the noise level by about 2½ dB (for QUART II) or 3½ dB (for QUART III) while still receiving an acceptable multi-channel sound; compatibility with 3-channel QUART receivers is also ensured.

The numerical coefficients of the rear channel modulations have been carefully chosen to optimise the noise performance. The writer believes that it would be difficult to find a compatible 4-channel multiplex system that would give significantly better noise performance, and most proposed systems would be considerably worse. Assuming that $\gamma = 5\%$ and that all four channels convey equal audio energies, then mono or stereo receivers tuned to a QUART II or III transmission will receive a signal 4.5 dB quieter than when tuned to a Zenith-GE stereo transmission (due to the energy used up by the extra two channels): 4-channel receivers receiving a 4-channel transmission will have a signal-to-noise ratio 7.5 dB (for QUART II) or 8.6 dB (for QUART III) worse than a stereo receiver receiving a Zenith-GE transmission under the same conditions. If we assume that the rear channels convey half the audio energy of the front channels, then the corresponding figures are 2.9 dB, 7.2 dB and 8.3 dB respectively.

QUART II is clearly technically superior to QUART III, and is preferable in countries not using SCA transmissions, notably in Europe. In countries using SCA transmissions, either the inferior QUART III system could be used, or QUART II could be used, and stations transmitting SCA subcarriers would then be restricted to using the 3-channel QUART system. However, due to the rear channel sum-and-difference technique, QUART II receivers could easily be switched to 3-channel reception. For the rear channels to be the correct way round, it is necessary to ensure that the polarity of a QUART III multiplex signal is correct. It may be necessary to use vestigial sideband modulation for the 95-kHz modulation in QUART III to avoid excessively high frequencies occurring and causing trouble with i.f. responses and adjacent-channel interference. **R-E**

THE CASE OF THE SIAMESE PENTODE

by **ART MARGOLIS**

The 'BU8 is a devil in the sync circuit. Common elements can cause not-so-common troubles.

"Here comes our sync specialist now", I heard Tom my benchman tell our two trainees in an exaggerated stage whisper. I smiled. He always ribs me about my writing endeavors and he was referring to my book "Servicing Sync Circuits."

I knew though, when he did this I was going to have to perform on the bench, and if I didn't fix the dogs they were saving for me quick, my name was mud.

Sure enough, as I rounded the corner there were three TV's set up on the big bench and turned on. The nearest one had running sync both vertical and horizontal. The middle one had agc trouble and the furthest one had both sync and agc.

John, a serious young student fascinated by electronics said, "Art, these are three that we ended up with last night."

Harry the other trainee gruffed from behind his red mustache, "Yeh, we ended up with them cause we couldn't fix them."

I looked the three jobs over. The schematics had been pulled and the sync-agc tubes had been replaced. One TV had a 3BU8, another was using a 6BU8 and the third had a 6HS8, all Siamese pentodes for sync-agc duty. Actually all three tubes are identical except for heater and other minor considerations.

The reason I call them Siamese pentodes is because they are different from the waist up while using the same elements from the waist down (see Fig. 1). That is, the two sections of the tube have separate plates and separate suppressor grids but have one common screen grid, one common control grid and one common cathode.

The reason for this unusual arrangement is to permit the suppressor grids to act as if they were control grids. This makes the top section of the tube into twin triodes. The bottom section of the tube is a complex biasing arrangement and from the point of view of the top section, the output from the bottom section could just as well be coming from a regular cathode.

However, the screen grid can contain a potentiometer that sets the conduction level for both sides of the tube and the control grid can turn on and turn off both sides of the tube at will. You'll see the value of these things as we go into the repairs.

Mystery of the running sync

The nearest TV was a 19" Motorola portable about five years old. The sync-agc function used a 3BU8 sharp cutoff Siamese pentode.

John said quietly, "I began checking it out. The dc voltages are all about right. There's 150 volts on the cathode, 150 volts on the control grid, 225 on the screen, about 110 on the suppressor and 250 on the plate. This is well within a 10% tolerance. The tube is conducting normally."

I nodded. The voltage difference between the cathode and the plate in a separator is set purposely low. Also the suppressor grid is set with a high negative bias. The high bias and low plate voltage keep the tube cut-off under normal conduction periods.

It takes a really strong positive voltage impressed on the suppressor grid to cause it to conduct. Coming into the suppressor grid, from a video takeoff point in the video output area, issues a steady stream of video. When regular positive video enters it tends to push the grid towards zero from its high bias, in this case the bias is minus 40 volts. (Difference between + 150 volts on the cathode and +110 volts on the suppressor).

The video itself with its positive voltage from zero to 75% of the total peak to peak input lowers the bias but not enough to cause conduction. The blanking voltage at its 75% level also is not enough to turn on the tube. However the sync tip at 100% pushes past the bias and turns on the tube (Fig. 2). That way only the sync pulse is amplified and appears in the plate circuit. Separation takes place.

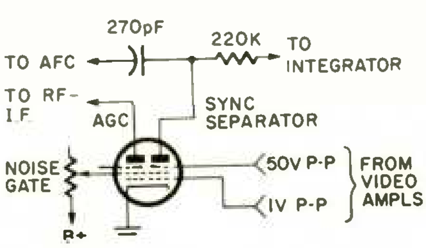


FIG. 1—TYPICAL SIAMESE PENTODE. The top section becomes twin triodes while the bottom section provides biasing.

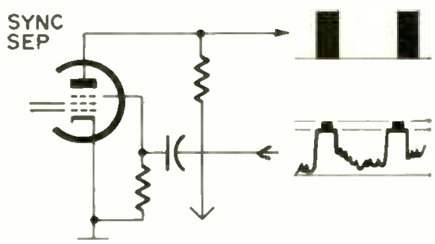


FIG. 2—ONLY THE SYNC TIP turns on the tube, is amplified and appears in the plate circuit.

In this Motorola, the peak-to-peak voltage called for on the schematic showed 50 volts peak-to-peak. I asked John, "Did you check the video input?"

He smiled guiltily, "The scope is over on the other side of the shop, I couldn't find the probe. . . ."

I laughed, "You don't need the scope, there is the P-P function on your vtvm."

His eyes lit up and he began taking readings. I watched over his shoulder. He set the vtvm for 140 volts

P-P and touched down on the plate. There was supposed to be forty volts there. The meter read zero. He touched down on the suppressor grid. There was supposed to be fifty volts P-P there. There was zero. He looked up at me.

I said, "That's good. You have a valid clue, trace back the video takeoff line from the suppressor."

There was a little parallel filter network in series in the line with a 220-pF capacitor and 470,000-ohm half watt resistor (Fig. 3). He crossed

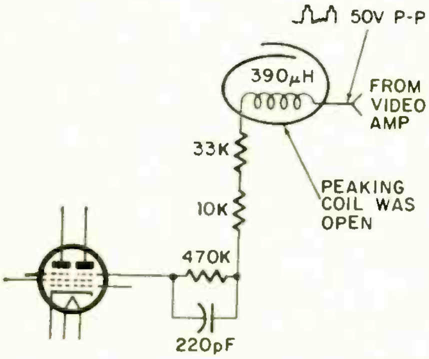


FIG. 3—AN OPEN PEAKING COIL stopped the peak-to-peak voltage from reaching the pentode.

over them and read their video input. Again zero!

Then he crossed over two series resistors and then a peaking coil. Voila! The fifty volts P-P appeared. He jumped the peaking coil temporarily. The sync stopped running and locked in solid.

Just for the heck of it he retested the suppressor grid and plate. The P-P was there and fine. Harry handed him a new peaking coil and the set was repaired. Harry quipped, "Now then Johnny old boy, wasn't that easy?"

John smiled gleefully.

Strong station only caper

Harry sat down at the middle TV and announced, "This one is mine!"

John said unsmiling, "Yeh, what are you going to do with it?" It was a Zenith chassis and exhibited a case of classic sync trouble.

The weak snowy stations from afar were coming in better than ever. The local stations were blacked out but still provided sound. The agc circuit was housed with the sync circuit in a 6BU8 Siamese pentode.

Harry began taking dc voltage readings. I didn't say a word even though that was not exactly the right first step. The correct step would have been to use a bias box and see if you could correct the condition. If the bias box did correct the trouble was definitely in the agc circuit. Should the bias box fail to correct, the agc symptoms were being caused by a defect somewhere in the rf-i.f. or video circuit. But since the symptoms were so classic I kept quiet for the troublemaker was obviously in the agc.

His dc voltage readings revealed nothing. The plate, suppressor, screen grid, control grid and cathode read exactly as the schematic would have them.

This type of circuit is keyed agc. That is, the tube won't conduct unless all of the right pulses are coming into the tube at the right time.

The plate has no B-plus on it. The screen grid has B-plus on it. The control grid has a normal negative bias close to the cathode voltage. The suppressor grid which acts like a control grid has a high negative bias. The tube unless acted upon by outside forces remains turned off.

Of course a turned off tube is worthless so outside forces are impressed on the tube. There are outside forces that especially key the tube on. One is a pulse of about 500 volts peak-to-peak from an agc winding in the flyback transformer. It's a 15,750 Hz pulse that is applied to the plate. That means when the peak of the pulse occurs on the plate, the plate is ready to conduct at that time.

Second, the composite video signal is taken from the video output area and applied to the suppressor grid. The composite video has a peak-to-peak of about fifty volts. This is just enough to let the 100% level sync pulse override the bias, while the video remains innocuous.

The flyback pulse and the sync tip arrive at their destination, the plate and suppressor respectively, at the same instant.

At that instant the key is turned in the lock. The tube turns on and a small voltage appears at the plate. The size of the voltage varies with incoming signal and is free of noise since noise appears mostly in the video.

The varying pulse is filtered and is applied to the rf-i.f. as agc voltage. With the TV exhibiting these symptoms the TV was bereft of agc.

"Now what," I asked Harry. He shrugged.

John pitched in, "Why not use the peak-to-peak tracing technique like we did in the sync job?"

Harry shrugged again, "Why not indeed?"

John switched Harry's vtvm to P-P and Harry began reading. The fifty volts P-P was on the suppressor as it should be. That meant the video input line was good.

The 500 volts P-P was on the plate. That meant the flyback pulse network was correct. The two of them looked at each other and then looked at me.

I asked, "Now what?"

Harry said, "The tube is performing perfectly. The trouble must be in the line from the plate to the tuner and i.f. strip."

He took a dc reading at the plate again. It was minus six volts as it should be. He crossed over a 2.2-megohm resistor. The minus six dropped to zero!

"Ah ha," he chortled and undid one end of the resistor. But his smile disappeared as the resistor read 2.2 megohms right on the nose. He tacked in a new one anyway. Didn't help.

Then he looked at the next thing in line. It was a shielded cable that carried the agc bias to the i.f. strip. He read the cable from center to shield. There was zero ohms (Fig. 4)!

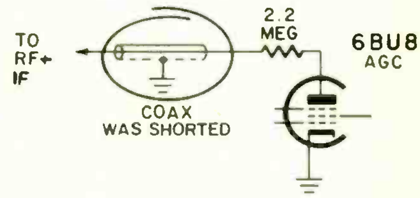


FIG. 4—A SHORTED SHIELDED CABLE killed the agc in this receiver.

He looked stunned. I spoke what was on his mind, "Yes, it looks like you have a shorted cable."

John handed him a new piece of cable and he whistled as he installed it in place of the shorted piece. That was it. The strong channels returned in perfect fashion.

We all turned to the third TV. I saw that it had. . . .

Double trouble syndrome

The picture was running sync but it was also overloaded so badly the picture was a negative. It was a Silvertone portable. They both said, "You can do that one yourself, Art."

I laughed and pointed authoritatively to the two stools by the bench, "You're the trainees, not me. I'll watch you both work though."

They sat down. Harry grabbed for the vtvm. I said, "I let you go on the last one because it was obviously agc trouble, but start off with the bias box, this time."

John brought the bias box over from our test equipment shelf and attached it into the first i.f. below the grid leak resistor (Fig. 5). He began adjusting it. At one critical point the agc cleared. The negative turned positive and the picture was clear. However, it still ran sync as badly as ever.

The two of them stared at the picture. I said, "Let's analyse this bit of service information."

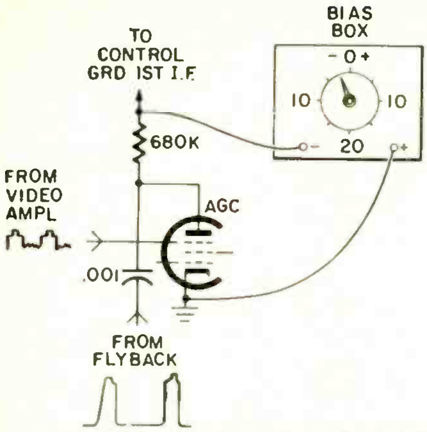


FIG. 5—A BIAS BOX can be substituted for the agc circuit while servicing a TV.

John said, "There are definitely two troubles, one agc and one sync."

Harry chimed in, "Let's find the agc trouble first and maybe it will be causing the sync trouble too."

I asked, "Is there any place in the circuit where agc and sync are both controlled by the same components? In other words, what components will cause both agc and sync to conk out?"

They looked and both blurted almost simultaneously. "They have common ties in the cathode, control grid and screen grid. They don't separate functions till they get to the suppressor grid in the 6HS8."

John began dc voltage checks. The screen grid was about thirty volts low. The control grid was about normal. The cathode was about normal. I said, "The screen grid controls conduction of the tube. The low screen voltage is cutting off the tube."

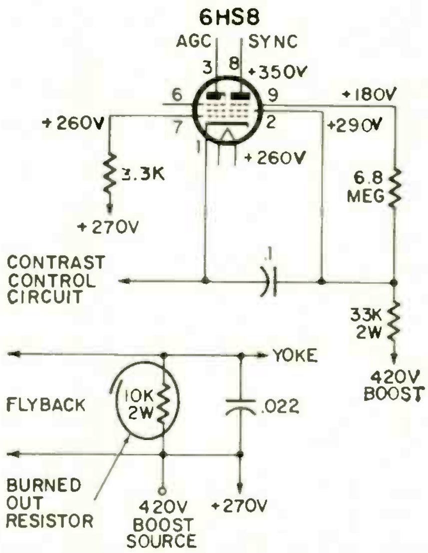


FIG. 6—RESISTOR IN THE BOOST circuit was causing the sync-agc trouble. It was burnt out.

John looked at the schematic (Fig. 6) and began checking the B-plus inputs to the screen. As he crossed over a resistor towards the power source he yelled, "There's supposed to be 420 volts B-plus here. There is nothing!"

We all looked and traced the circuit back to its source. It was in the damper circuit. There was a 10,000-ohm resistor that looked like it had had it. It was slightly charred with a crack down the center. There was good boost B plus on its other side. A new resistor restored all.

What had been confusing was, there were two B-plus inputs into the screen. The boost voltage only supplied the additional thirty volts that had been missing. One doesn't usually look in the damper circuit for sync-agc answers.

John said, "I read your sync book cover to cover and you didn't tell about these troubles."

Harry continued, "Yeh, what about these troubles?"

I asked. "What would you like me to do write an article and tell how you two licked these tough dogs?"

They both echoed, "Yeh, and be sure to mention our names." **R-E**

IC MODULAR TV

(continued from page 64)

receiver, however, will result in a voltage drop across the 1.8-ohm R4 that will make the emitter more negative than the base and cause conduction. At 450 mA supply drain, Q1 is conducting hard and switches its lowered emitter potential to the base of Q800 reducing its conduction, thereby protecting the entire power supply. When the short is removed, Q1 and Q800 all return to normal operation. This is called foldback current limiting, and is extremely useful in all semiconductor powered equipment.

The Second Quasar II to be produced is the CTV6 with conventional chassis construction, a transformerless half-wave voltage-doubler, low-voltage supply, and a polarized ac line plug with one side of the power line going to the chassis. An auto-transformer supplies the paralleled heaters of the four vacuum tubes and the CRT.

The high-voltage supply (Fig. 3) is relatively conventional, having grid-leak bias of about 70 volts on the horizontal output tube. However, the grid circuit includes a simple regulating circuit that controls the high-voltage level. The H V BIAS control is set initially for 27 kV on the CTV6, and for 21-kV on the CTV5. Thereafter, a positive feedback pulse from the primary of the flyback controls the decrease in resistance of VDR R502 so that a larger than normal pulse increases bias, and a smaller pulse decreases the bias. The ratio between the CRT's beam current and high-voltage output is therefore preserved. When one increases, the other decreases. Thus the high voltage is regulated . . . all without a series or shunt regulator.

In some receivers, Motorola has devised a 2-diode, 2-resistor, 1-capacitor circuit (Fig. 4) to continue to supply protective negative voltage to the grid of the horizontal output when the horizontal oscillator or driver fails. Diode D1 rectifies an ac input and charges a 0.22-μF capacitor to -160 volts. This is bucked by whatever voltage from 700 volts B-boost that can appear at the cathode of D2. This diode is back-biased by the -70-volt grid bias until some drive failure occurs. When negative grid-leak voltage is lost, D2 becomes forward biased and supplies enough negative grid bias to keep the output plate and screen currents within safe limits. The more the high voltage and B-boost voltages drop, the more negative pulsating dc is applied through D2 to hold the output tube at or close to cutoff.

The CTV6-S1 (model HP558GW) is further modified to include channel blanking, 75- and 300-ohm antenna connections and a secondary volume control (set from the rear of the receiver) to limit the maximum audio level that can be obtained from the front-panel volume control. The CTV6 has all the plug-in panels of the CTV5 but is a little less costly to produce and is manufactured with 17-inch and 19-inch picture tubes. The CTV5, on the other hand, is available in picture-tube sizes from 19 to 25 inches and in both table and floor models. **R-E**

TECHNOTES

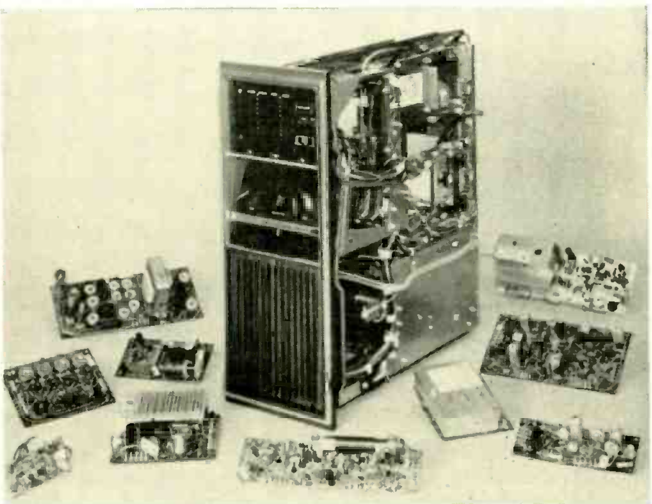
QUICK CAPACITOR TEST

Use this quick method for testing audio coupling capacitors for leakage. This can be done without unsoldering any wires. Connect a voltmeter across the primary of the output transformer and momentarily short the plate of the driver tube to ground or B minus.

If the plate current of the output tube decreases (the voltage across the transformer drops) when the plate of the driver is shorted, the coupling capacitor is leaky and should be replaced. No damage will occur to the rectifier ac-dc radio or TV sets due to this procedure, since the load resistor of the driver tube is very large.—*Harry J. Miller*

What's new in modular and IC color TV for '71

Inside Motorola TV chassis you'll find several changes for '71. Here's a close look at the important ones



by STANTON R. PRENTISS

EVEN THOUGH 1970 SPRING SALES WERE A BIT SLACK, THE new color receivers just introduced for 1971 continue the trend for easier servicing and major circuit innovations. Three major companies are now offering hybrid and solid-state plug-in modular color receivers, while others have slide-out chassis, plug-in transistors, and most are featuring at least one or more integrated circuits (IC's) in the audio and chroma circuits. Some picture tubes have reached 25 inches diagonally. Receivers in many lines are hybrid combinations of transistors and four or five power output vacuum tubes. Much of the semiconductor design engineering is indeed a pleasure to behold. Chroma oscillators are formed from logic gates. Color is demodulated after and with b-w information, voltage-regulated IC's are commonplace, amplifiers, limiters, switches, SCR's, high-voltage triplers, quadruplers, low-voltage regulation with fold-back current limiting, and plug-in tuners that can be replaced in the field are all part of the new year's fascinating exhibition of the all-American competition.

Coupled with further refined color picture tubes and less hazard of X-radiation than ever, the new receivers are indeed instruments of beauty and great electronic progress.

The original, Motorola

Three years ago, Motorola introduced the Quasar. This 23-inch receiver consisted of ten modular plug boards (video i.f., afc, audio, video amplifier, color, video driver, video output, convergence, pincushion, and horizontal sweep) with power transistors in sockets on the chassis, mounted in separate sections. The TS-915 and TS-919 chassis are physically much the same today but with significant internal changes among the video drivers, video amplifiers, color circuits, the horizontal sweep and a solid-state high-voltage rectifier.

This receiver never used a high-voltage regulator because the dc supply for the paralleled horizontal output transistors has always been regulated by circuits on the pincushion panel that supplied them through a winding on the flyback transformer. Since the horizontal-output transistors are regulated, there is also an automatic brightness control to govern conduction of the video drivers, limit the flow of beam electrons as well as preventing the high-voltage supply from drawing excessive current. Developed too was the diode tri-demodulation system to permit direct demodulation of all red, green, and blue chroma voltages along with the luminance information, so that the final output was an R-G-B system to drive the picture tube cathodes directly and keep the grids at a steady dc potential. Because there is hardly more than 100 volts dc between cathodes and grids at any one time, the chances for arc-over is greatly diminished, there is less stress on the tube, and the colors and fine luminance detail are satisfactorily reproduced.

Still in the design are the diode bridge and separate half-wave diode power supplies that develop the various voltages for small-and large-signal transistors in the receiver. There is also a special 6.3-volt transformer that permits the picture tube heater to remain slightly on while the remainder of the receiver is turned off. This feature allows the tube to warm up in several seconds and produce a bright, contrasty picture as soon as the transistorized high-voltage builds up. The result is an instant-on color picture that does not initially turn negative and is relatively constant after adjustment of chroma, hue, and contrast settings.

Just to make the picture complete, Motorola, in the last two years, developed an ac regulated supply for the entire receiver that has appeared on the deluxe models and automatically controls ac line variations between 105 and 130 volts for a constant receiver input of 117 volts. This ac regulation plus the filtered dc regulation has given the top-of-the-line Quasar receivers a constant supply voltage.

Plug boards for this and other Quasar-type receivers with all components mounted (see photo) are removable usually with fingers but sometimes need the aid of a quarter-inch nutdriver where secure grounds are required. They are fastened over plastic mounting studs that seldom require undue pressure when either mated to or separated from their locking connectors. Detailed service manual charts make usual trouble-shooting procedures relatively easy so that boards can be removed and exchanged in the home for rapid repairs. These boards are coded according to the latest changes and modifications. If, therefore, you have a two- or three-year-old receiver and want it updated for better video and chroma response, you can have boards with the latest modifications installed by the servicing dealer. Horizontal sweep, color, video amplifier, driver and video output panels should do the trick; you might get by with less. And if you wish to go even further and install a new color bright picture tube, you'd virtually have Motorola's latest Quasar.

Top of the Line

The top-of-the-line Motorola receivers for 1971, two plug-board chassis: the 25CTS-915, and the AD25TS-915. The 25CTS-915 features ac-line regulation, uhf and vhf afc, special (Paktron) ac-line bypass capacitor, Nomex insulated flyback transformers, "quick-on" with defeat switch, new earth's field magnetic shield, larger degaussing coils, slide-type pots for hue and intensity (no separate tint control), and solid-state high-voltage rectifier.

The AD25TS-915 is the ultra chassis for "stereo theatres" and two fancy consoles. In addition to all the features of the previously described chassis: it has power tuning, power indicator light, all remote control (no manual models), concealed customer controls, swing out front panel for greater serviceability, IC audio, new rf grounded base vhf Oak tuner, and the very new Memomatic mechanism and varactor-tuned uhf tuner supplied by Hopt of Germany. This tuner can be programmed for 13 channels, and will probably be set locally for individual vhf and uhf stations.

The four-varactor uhf tuner operates on the principle of a programmable voltage being applied to voltage sensitive diodes. The diode behaves like a reactive capacitance and changes the frequency of the front-end to tune the various channels.

To produce an economy version of the all solid-state receiver yet retain most solid-state advantages, Motorola has gone hybrid with two significant receivers—both labeled Quasar II—for 1971.

The CTV5 hybrid Quasar II

For the less than fully-transistorized receivers, the CTV 5 (TS-934), is Motorola's mainstay. Still with "the works in a drawer," it has four vacuum tubes (one dual

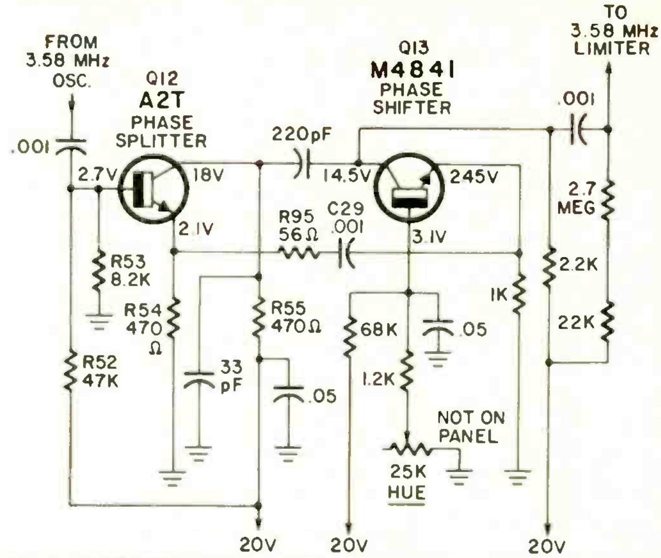


Fig. 1—THE NEW HUE CONTROL shifts phase of 3.58-MHz signal by varying dc bias on base of Q12. This arrangement is simpler than the ac control in earlier sets.

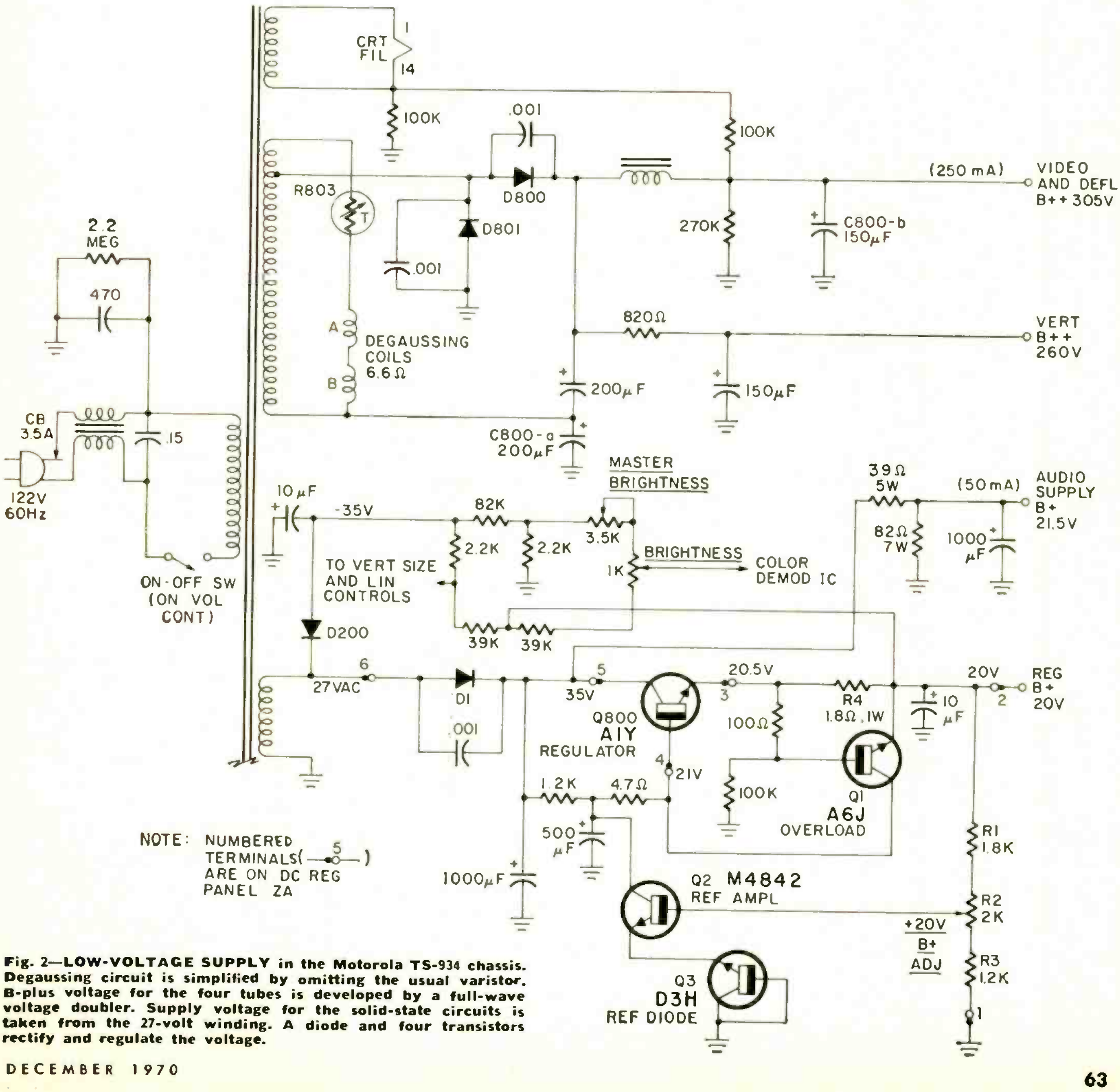


Fig. 2—LOW-VOLTAGE SUPPLY in the Motorola TS-934 chassis. Degaussing circuit is simplified by omitting the usual varistor. B-plus voltage for the four tubes is developed by a full-wave voltage doubler. Supply voltage for the solid-state circuits is taken from the 27-volt winding. A diode and four transistors rectify and regulate the voltage.

purpose) for vertical oscillator, vertical output, horizontal driver, horizontal output, and damper. Including uhf and vhf tuners, there are 42 transistors, 2 integrated circuits, 18 diodes, and 6 plug board removeable panels for the i.f.'s and audio, color-video panel, horizontal and vertical deflection panel, low-voltage regulator, convergence panel, and aft. Basically the same design as the later TS-915 Quasars, the Quasar II has an integrated-circuit tri-color demodulator that supplants the original video drivers and demodulates red, blue, and green signals directly with the luminance information already mixed in. There is also an audio IC that contains the 4.5-MHz i.f. amplifier, limiter, quadrature-type FM detector, and af preamplifier. The preamp drives a transformerless complementary symmetry audio output that has negative feedback along with dc coupling for both good stability and low-frequency amplification.

The hue control in Quasar II (Fig. 1) is new. It is a dc voltage-divider potentiometer in the base of the 3.58-MH-phase-shifter as opposed to a ac phase-shifter in the collector-emitter circuit of the color-oscillator phase splitter in the original Quasar. The 3,579,545 ±10Hz subcarrier sinewave is applied to the base of the phase splitter (Q12). Resistors R52 and R53 from the 20-volt supply to ground provide a constant base voltage of 2.7 volts. Resistors R54 and R55 in the emitter and collector are equal value resistors that will permit a certain out-of-phase and in-phase voltage swing between V_{cc}, the collector voltage, and ground even though the collector has 18 volts dc and the emitter only 2.1 volts dc. Resistor R55 is the load resistor for the A2T phase splitter and R60 is the load resistor for phase shifter Q13. Collector-to-collector coupling ac between Q12 and Q13 is through a 220 pF capacitor. Whenever the arm of the HUE control is at ground potential, the phase shifter will not conduct, and reverse phase 3.58-MHz sinewaves at the Q12, Q13 collectors are passed through the limiter (not shown) to the three red, blue, and green demodulators. With the HUE control arm turned toward its open end, the dc voltage division is less, more base current flows and the phase shifter conducts hard and mixes a great deal of amplified in-phase voltage coming from the R95–C29 coupler network and the Q12 emitter. This signal shifts the 3.58 MHz information in an opposite direction from the period Q13 was cut off and so changes the angle of demodulation and the resulting hue or tint of the picture. In between cutoff and full conduction, the phase shifter produces partially mixed 3.58-MHz sinewaves of varying phase. Usually, good tint controls introduce vector phase shifts of from 90° to 100°. This arrangement, however, can produce a total variance of 150°, and can be adapted for remote operation since dc can be applied directly from the control voltage of a remote memory module.

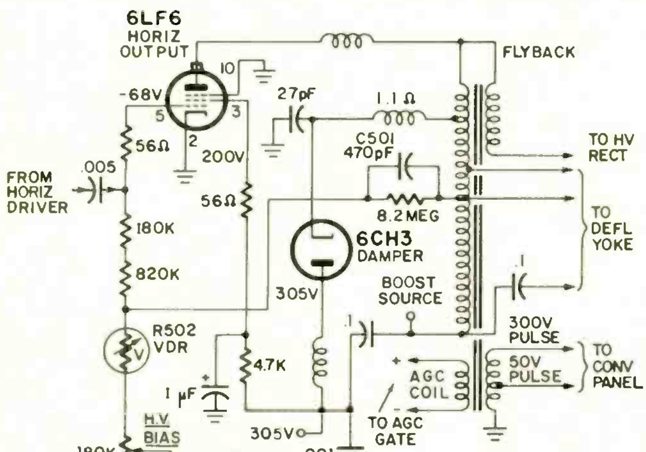


Fig. 3—HIGH-VOLTAGE REGULATOR in the Quasar II receivers. The effective resistance of voltage-dependent resistor R502 depends on amplitude of pulse from flyback through capacitor C501.

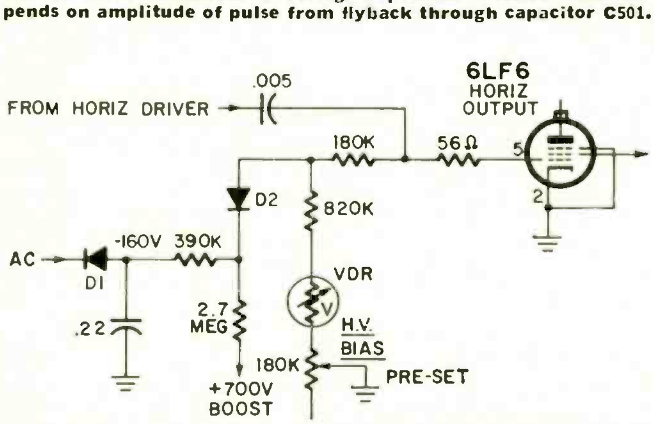


Fig. 4—DUAL BIAS SOURCES protect output tube against excitation failure. Adequate driver signal biases grid to —70 volts and blocks D2. If drive drops off, D2 conducts and biases the grid negative from the bleeder between B-boost and —160V.

Interesting low- and high-voltage supplies

This receiver has many more interesting circuits. Two of these are the low-voltage regulator and the high-voltage supply.

In Fig. 2, we have a full-wave voltage doubler and a regulated supply for the solid-state devices. With incoming current flow, the degaussing coils pass current through their 6.6 ohms resistance and through thermistor R803. This element has a positive temperature coefficient—resistance increases with temperature. The set is degaussed promptly each time it is turned on because R803 is initially cold and current flows freely through its low resistance. Upon warm-up, the resistor quickly increases in value and removes the shunt across the upper secondary of the transformer. On the first negative-going alteration (the top end of the winding is negative with respect to the bottom end), rectifier D801 conducts, charging C800-a to some positive voltage above ground. On the positive-going half-cycle, D800 conducts and places a positive charge on C803. The charges on C800-a and C803 are in series so they add and charge C800-b and C801 to about twice the transformer's peak voltage output. This dc source is then divided into two supplies, one of 305 volts at 250 mA, and the other at 260 volts with a current drain of 50 mA—a very important criterion to know when IC or transistor troubleshooting.

The lowest secondary furnishes a —35 volts the VERTICAL LINEARITY, VERTICAL SIZE, BRIGHTNESS and MASTER BRIGHTNESS controls; furnishes ac for the positive 20-volt regulated supply, and for an unregulated 50-mA 21.5-volt source for the audio section.

Most of the regulator, including rectifier D1, is on plug board ZA. Rectifier D1 supplies filtered dc voltages to the collector of Q2 and the base of regulator Q800. The regulator is forward-biased and conducts normally, switching a voltage through its emitter to and through current limiter R4 to the output. This output voltage is then divided down through R1, R2, and R3, and a portion permitted to flow back through the arm of R2 to reference amplifier Q2. Transistor Q3 is connected as a reference Zener and holds the Q2 emitter voltage at a steady potential. Conduction of Q2 is adjusted by potentiometer R2 to supply the necessary base current for regulator Q800 so the output is a regulated 20 volts.

Usually this circuit furnishes 250 mA and overload transistor Q1 is back-biased and not normally conducting. Current drain by some short on the 20-volt bus in the

(continued on page 61)

What can an electronics technician do to achieve recognition for his proficiency in electronics? What can he do to prove to himself and to others that he is competent in his field?

CAREERS in ELECTRONICS

blueprint to your future

by LOUIS E. FRENZEL, JR.

Your knowledge, experience and proficiency are valuable assets. Here is how to get the recognition you deserve.

FCC LICENSE shows proficiency, lets you service transmitters. *(Photo courtesy CREI)*

Other professional and semi-professional people have numerous means of gaining recognition. For example, doctors can point to the college degrees and the state medical licenses that they receive when they pass the state medical examination. Lawyers, like doctors, can point to their college degrees and their licenses to practice. Engineers, accountants, insurance, real estate and stock brokers have similar means of achieving recognition and proving their competence in their given fields.

All of the states give examinations to register a man as a professional engineer. Accountants must take a rigorous examination if they are to become CPA's. Insurance, stock and real estate brokers must also pass comprehensive exams before they can practice their professions.

Electronic technicians have similar means of achieving recognition. While not as well known as those for doctors, lawyers, and other professional people, the programs of recognition available for electronics technicians are just as important and can be quite beneficial. As an electronic technician you will most assuredly be interested in these means of proving your capability in your field.

Your school diploma

Your first and probably most important form of recognition is your school diploma. This diploma signifies that you have completed a formal training program in electronics. It is the very first form of recognition that you receive as a technician. It proves to you and to anyone else that you do have a basic education and proficiency in electronics.

If you do not have a formal education in electronics leading to the award of a diploma, then it will most certainly be to your advantage as a technician to obtain one. If you cannot attend a resident school, try a home study school. The time, money and effort will be well spent. It is the best investment you can make for your future.

If you work in the electronics industry as a technician, you know that recognition beyond your basic electronics education can come in many forms—money, position, responsibility, etc. If you do a good job, you will earn more money. If you continue to perform well, you may be promoted into a higher position and given more responsibility.

This is the kind of recognition we all want and need. However, there are several other, more formal means of achieving recognition and showing your proficiency in your chosen field. And showing your proficiency in these formal ways can ultimately lead to recognition by position, money and responsibility.

There are three agencies or organizations whose purpose it is to evaluate technician qualifications. They investigate the technician's education and experience and formally test his ability in electronics through a written exam. Of course, in most cases, none of the certificates or licenses issued by these organizations are actually required to work as a technician. However, by voluntarily applying for these certificates or licenses, a technician can prove his ability to others through this form of recognition.

Certified electronics technician

The National Electronics Association Inc., sponsors a recognition plan known as the Certified Electronics Technician Program. This is a program where electronics technicians with a certain amount of training and experience can become certified by this organization as electronics technicians. By meeting the experience and educational requirements as well as passing a comprehensive examination in basic electronics, you can earn a Certified Electronics Technician diploma. By showing proof of your experience and by passing the required examination, you illustrate to yourself and others that you are capable in your field.

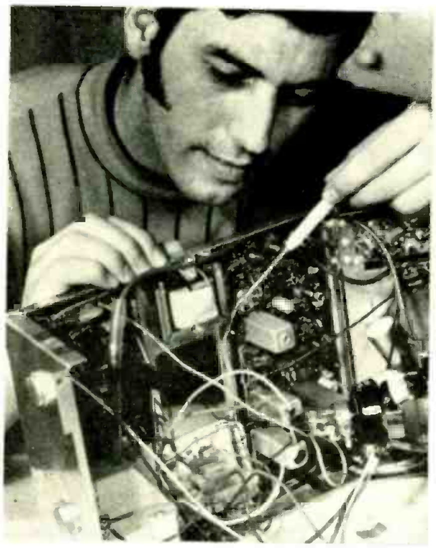
The Certified Electronics Technician program was developed particularly for technicians working in the consumer electronics fields of radio, television and hi-fi repair. While this program is aimed primarily at these people, technicians in other fields may also qualify. The program requires four years of experience in electronics, some formal education in electronics through a correspondence course or a residence school, and passing a 126-question exam on electronics and television.

If you meet the education and experience requirements, you are eligible to apply for certification. There is a $5 fee for taking the test. This fee covers the expenses involved in preparing and grading the test and in processing your certificate.

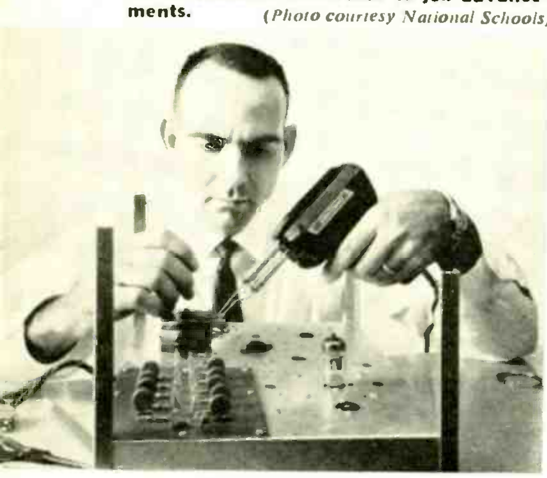
If you are interested in this program, write to Mr. Leon Howland, Chairman, NEA Certification Program, 4622 East 10th Street, Indianapolis, Indiana 46201 for further information.

FCC licenses

An FCC license is a certificate issued by the Federal Communications Commission to technicians who pass an examination in basic electronics and communications. The license is



HOME-STUDY TRAINING prepares you for certification that leads to job advancements. *(Photo courtesy National Schools)*



(Photo courtesy National Radio Institute)

the government authorization that permits the technician to operate, repair, adjust and maintain the electronic equipment used in various communications services—broadcasting, mobile radio, marine radio and others.

The government wants to be sure that the equipment used in the communications services, particularly the transmitting equipment, is properly adjusted and maintained to meet the rules and regulations established by law. It can't permit off-frequency or distorted signals to occur, nor can it allow interference between stations. For that reason, the technicians who operate and maintain the equipment must be fully competent. The FCC examines these technicians to determine if they do have the basic knowledge and skills to ensure success in handling the equipment, and then issues a license to certify the technicians competence.

Justification for a license

Should you get an FCC license? If you plan to work as a technician in radio or TV broadcasting, two-way mobile radio or marine radio, you must have an FCC license. The law requires it. However, even if you aren't working in one of these areas there are several reasons for considering a license.

While it may not be a necessity to your work or goals, it can be of value. Here's why. First, since the FCC license is awarded only after you pass a comprehensive test in basic electronics and communications, it proves that you do know electronics. It's pretty tough to pass the FCC exams without a knowledge of fundamental electronics. Having an FCC license is sure proof that you do have a certain level of knowledge and competence in electronics. The license is truly a measure of your achievement as an electronics technician.

Another reason for getting an FCC license even though you may not need it, is the feeling of accomplishment that comes from passing the tests. It is a big boost to your pride and morale. Getting an FCC license is a real shot in the arm for some people. It can give you the self-confidence you need to get ahead in electronics.

It doesn't really matter whether you are a radio-TV service technician, an industrial electronics technician or a hobbyist; an FCC license could put a few extra bucks in your pocket. As a radio-TV service technician with an FCC license, you can get into the lucrative mobile radio field. There are thousands of mobile radios in taxis, police and fire vehicles, and in industrial and commercial vehicles that need frequent repair, adjustment and checkout. This work is required by the FCC and there is always a demand for trained people to do it.

There is also Citizens band (CB) radio equipment. Many non-technical individuals and businesses use CB radio for communications. There are millions of CB radios in use and they too require the services of an FCC licensed man to adjust or repair them. This could be a good money-making sideline for the technician with a license.

Marine radio equipment also needs regular repair and adjustment. Many boat owners with such radio gear often wonder who to turn to for this service. Since most boating seems to be done on the weekends, you may be able to pick up some extra cash on weekends by providing this service.

If you are looking for a part-time job, you may be able to find one as a transmitter engineer in the evenings at a local radio or TV station. All radio/TV broadcast stations must have FCC licensed transmitter engineers. And since many stations operate around the clock, they often have trouble finding licensed personnel to fill these positions.

Many employers of technicians recognize the FCC license as an achievement and often base their evaluation of a man's qualifications on this license. It can literally pay you to have one.

How to get a license

Getting an FCC license isn't easy, but if it were anyone could pass the test and it wouldn't mean a thing. You must have a pretty good understanding of electronics to pass the rather comprehensive exam they give. But if you have had some electronics training and you are willing to spend a little time boning up, then you shouldn't have any trouble.

There are several different types of FCC licenses. There are amateur radio licenses for the hobbyist. There are the commercial radiotelephone and radiotelegraph licenses. Ship radio operators and coastal telegraph station operators are required to have the radiotelegraph license. These licenses require skill in sending and receiving code. While the license is valuable to people in these fields, it may have little practical value to you.

The radiotelephone license is the most useful. It is the type required by radio and TV station engineers, mobile radio repair men and others. No knowledge of the code is required. There are several grades of this license, but you should try for either the 1st or 2nd class license.

The 2nd class radiotelephone license exam tests your knowledge of basic rules and regulations, radio operating procedures, basic electronics and radio. The license will permit you to service CB and all other mobile radios and to serve as an assistant or junior engineer in a radio station.

The 1st class license requirements are identical to those of the 2nd class, but you must take an additional 50-question exam on advanced radiotelephone electronics including TV. This license will give you full privileges in any radio or TV station. This is "the" license so to speak, as it carries the most weight and prestige. The best approach may be to do it step-by-step. Get your 2nd class license first, then you can study further and later take the additional test for the 1st class license.

There are several ways to prepare for the test. If you've already had some training in electronics, half the battle is already over. All you really need to do is to get hold of one of the many published FCC license study guides. Check with your local bookstore or electronics dealer. Most of them stock these books.

These study guides present many sample test questions and answers. Typical test questions are explained in detail. In some cases you may want a reference text to refer to for additional information. Your library should be able to supply this too.

Once you've done your homework, you are then ready to take the exam. Get in touch with your local FCC office. There are FCC offices in most major cities. Check your phone book under U.S. Government offices for the number and give them a call. The field engineer there will give you the details on date, time, and place of the tests. Also request application form 756. This is the form to use in applying for the license. It costs $5 for a 1st class license or $4 for a 2nd class license.

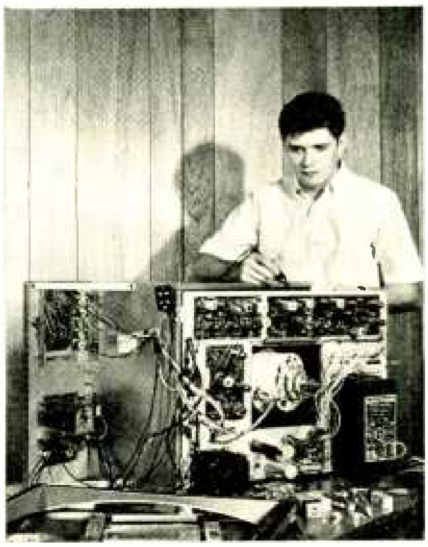
Certified engineering technician

If you are an engineering technician there is another program that you can pursue for further recognition in your field. An engineering technician works with or for engineers in carrying out various types of engineering work. This may involve assisting the engineer in the design of new devices or it may involve the installation, operation or maintenance of some complex equipment. The work may also involve drafting, sales, education, writing or other phases of engineering. If your job involves any of these functions then you are probably qualified to be certified as an engineering technician.

The Institute for the Certification of Engineering Technicians (ICET) is an organization established to evaluate the qualifications of those technicians who voluntarily apply for certification. If a technician is found qualified by his education and experience, he is awarded a diploma certifying that he is a qualified engineering technician.

To become certified you must have a certain amount of basic education and experience in your field. There are three grades of certification in the ICET program. The junior engineering technician grade requires that you have at least two years of work experience in your technical field. If you have the necessary experience and receive the endorsement or recommendation of an engineer for whom you have worked, you can be certified as a junior engineering technician.

After five additional years of applicable experience as a junior engineering technician you can upgrade to the engineering technician level. You must be at least 25 years old to achieve this level and must be endorsed or recommended by two professional en-



COLOR TELEVISION is but one of the many electronics fields you can enter. Your school certificate is a must for some jobs.
(Photo courtesy National Schools)

gineers or the equivalent. In some instances you may be required to take a basic examination to further prove your qualifications for this rating, particularly if you do not meet the basic education or experience requirements. The exams test your ability in English, drafting, math, basic physics and in one of five electronic specialties.

The highest grade of certification is senior engineering technician. For this grade, you must have had at least ten years of experience beyond that required for the engineering technician position. In addition, you must be at least 35 years old. Again you must be recommended or endorsed by professional engineers or someone of authority to recognize your capability.

The ICET program for technician certification is a widely recognized program. At the present time there are over 16,000 certified engineering technicians in the United States. Many employers recognize certification as a valid means of showing their recognition and proving your capability. Many technicians have received increases in salary and position by becoming certified. Because of the various grade levels in the program, it gives you some incentive to work toward a higher grade through improved capability and experience.

In most cases, you can become certified by simply making application. If you have the necessary number of years of appropriate experience plus some formal education, you will be certified. If your experience is not in the proper area, you may be required to pass the exams mentioned earlier to show your capability in the desired area. The fee for becoming certified is $10. This covers the cost of administering the program and of the certification diploma. A fee of $2 per year is charged for renewal of your certification. The examination fee is $25.

If you have had some formal education and have a number of years of experience as an engineering technician who has done some form of engineering support work, then you may be qualified for certification. Write the Institute for the Certification of Engineering Technicians, 2029 K Street,

(Photo courtesy CREI)

N.W., Washington, D. C. 20006 for additional information.

As you can see, there are a good number of ways of achieving recognition as an electronics technician. Your school diploma marks the beginning of this recognition while the Certified Electronics Technician program, the FCC license and the Engineering Technician Certification Program are all additional ways of proving your competency in electronics. You may find that one or possibly all of these programs fit your particular situation. In any case, it is most certainly worthwhile for you to investigate these means of achieving the recognition you deserve as an electronics technician. Wouldn't your school diploma, FCC license, and certification certificates look good hanging on the wall of your office, shop or den? You bet they would. **R-E**

1970 ANNUAL INDEX

RADIO-ELECTRONICS January-December 1970 of Vol. 41

*Construction articles; † part of larger article, ER (equipment report), NC noteworthy circuits, Corr (correction), CI (service clinic); P (programmed)

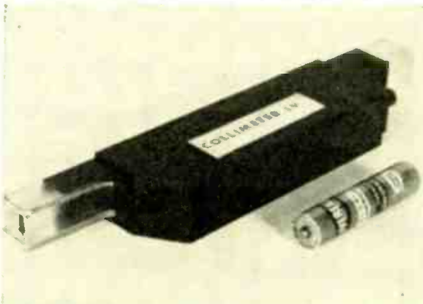
(continued on page 74)

Circle 18 on reader service card →

NEW PRODUCTS

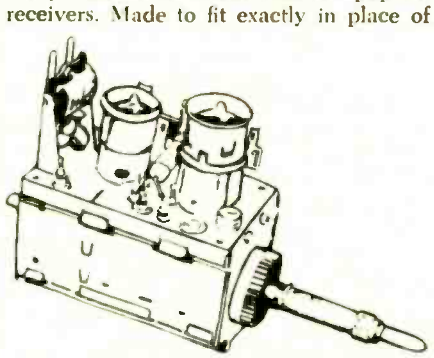
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 89 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

TAPE HEAD ALIGNER, *Collimeter IV*, is an electro-optical device for precision alignment in height, zenith, and azimuth. Offers consistent tracking, reproduction and fidelity. Calibrated to NAB specifications, it can be used with all stereo and mono machines. With optical magnification and an internal light source in one mode, pole piece wear and scoring is readily detectable. In the second mode the lamp triggers on only when sensors detect the proper zenith. $13.95.—**Ramko Research**, P.O. Box 6031, Sacramento, Calif. 95860



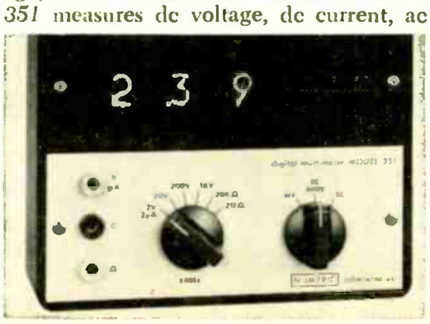
Circle 31 on reader service card

REPLACEMENT TV TUNERS, for many models of tuners used in popular receivers. Made to fit exactly in place of original tuner, color or black and white. $15.95—**Castle Television Tuner Service**, 5710 N. Western Ave., Chicago, Ill.



Circle 32 on reader service card

DIGITAL MULTIMETER, *models 350, 351. Model 300* measures dc voltage, dc current, and resistance. *Model 351* measures dc voltage, dc current, ac voltage, ac current and resistance. Both units have 1% accuracy. Other features include an automatically positioned decimal point and a sample rate of sixty per second. Both weigh less than 2 pounds. Model 350, $179; Model 351 $195.—**Numeric Laboratories**, 329 S. Greenwood Ave., Palatine, Ill. 60067



Circle 33 on reader service card

UHF-TV BOOSTER, *model DSU-105*. A high-gain, low-noise, 75-ohm preamplifier for uhf-TV channels 14 through 83. Employs stripline constructed transistors with low radial lead inductance to minimize noise. It is radiation proof and housed in a mast mounted aluminum casting. $150.—**Jerrold Electronics Corp.** 401 Walnut St., Philadelphia, Pennsylvania 19105.

Circle 41 on reader service card

VIDEO/RF SELECTOR, *model CCV3*, is a three-position control center for video or rf layouts. It can control 3 TV cameras and a monitor, or 3 monitors and one camera, or for switching low-power rf antenna systems, etc. Uses standard "M" type (SO-239) connectors on input and all outputs. No external power is required for operation. $19.95—**Alcoswitch Div. of Alco Electronics**, P.O. Box 1348, Lawrence, Mass. 01842

Circle 35 on reader service card

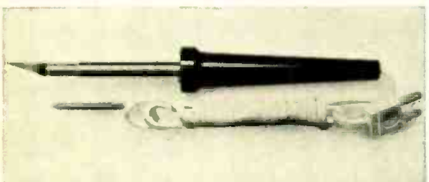
LOUDSPEAKER EQUALIZER, *model SE-111*, now includes integrated circuitry for higher performance. Signal-to-noise ratio is in excess of 80dB while harmonic and IM distortion are both below 0.1% @

2V rms output. Provides a total of 35 equalization curves to flatten and extend

frequency response, and is compatible with all speaker systems. Includes oiled walnut cabinet. $149.95.—Elektra Amplidyne Research Co. P.O. Box 698, Levittown, Pa. 19058

Circle 36 on reader service card

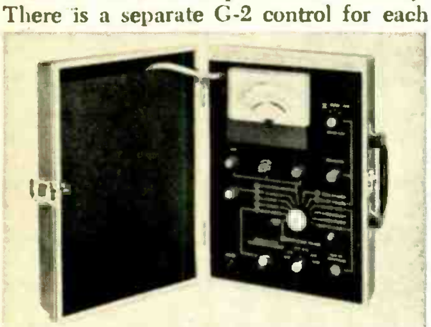
HOT KNIFE AND SOLDERING IRON, *model SP23HK*, is a dual purpose tool with a removable adapter chuck holding standard knife blade. With the chuck removed, the soldering tip can be screwed in. The 25-watt tool, when used as a



knife will cut most light plastics and epoxies, strip insulation from wires and carve foam plastics. For electronic hobbyists and service technicians. Complete kit is $4.98. Weller, 100 Wellco Road, Easton, Pa. 18042

Circle 37 on reader service card

CRT TESTER/REJUVENATOR, *model 466*, for black and white and color picture tubes. Tests for opens, shorts, or leakage between elements. Rejuvenates guns, repairs shorted or leaky CRT's without removing from set. Monitored rejuvenation permits reading relative cathode emission improvement directly. There is a separate G-2 control for each



color gun and sufficient G-2 voltage range to check color guns to cut-off at recommended voltage setting. CRT elements cannot float free. Key elements are connected to test points with all others shorted to ground. $129.95—Dynascan Corp. 1801 W. Belle Plaine Ave., Chicago, Ill. 60613

Circle 38 on reader service card

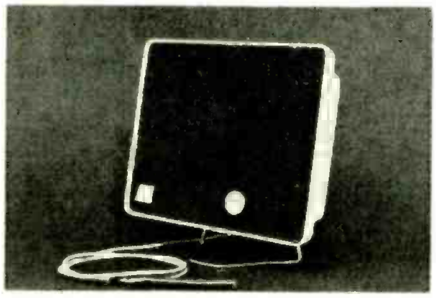
BACKGROUND MUSIC DECODER, *model SCA-2*, wireless adapter. Place sensitive pick-up coil near an FM set's i.f. stages to detect radiated i.f. signals. Unit reamplifies them with an integrated circuit i.f. strip and feeds them to a

Circle 78 on reader service card

Circle 79 on reader service card

Circle 61 on reader service card

decoder circuit, and on to a 1-watt IC audio amplifier which drives self-contained speaker. Unit has an output jack



for feeding the program material to higher powered amplifiers and speakers. Housed in a bone white injection molded polystyrene case. $89.95.—**S.C.A. Services Co.** Box 601, Port Washington, N.Y. 11050.

Circle 39 on reader service card

CHROMACUBE—*model AX-7*, combines dynamic colors of light, physical motion, and unique sculpture for home

entertainment, decor and illumination. Classic cube shaped in white plexiglass on a walnut-grained base. A rainbow of color light images moves on all five sides, each side 18". Functions as an audio responsive color organ by changing patterns according to the sounds of radio, hi-fi, etc. Can be a table, a lamp, a piece of sculpture, or combination. 5 models starting at $49.95—**EICO Electronic Instrument Co**, 283 Malta St., Bklyn, N.Y. 11207

Circle 40 on reader service card

FOAM TUNER CLEANER, *Magic Vista*, comes in an 8-ounce aerosol can. Included with the dispenser is a plastic spray extension tube for reaching tight places. Constant discharge valve allows

using of the spray at any angle. The foam cleans, polishes and lubricates TV tuner contacts without running, and is safe for plastics. $3.85.—**GC Electronics**, 400 S. Wyman St., Rockford, Ill. 61101

Circle 34 on reader service card

OSCILLOSCOPE, 5-inch solid-state *model WO-505A* features flatface cathode-ray tube, return-trace blanking circuits, illuminated graph screen, camera mounting studs. 15 mV peak-to-peak per inch gain on high-sensitivity range. Vertical amplifier—flat within, ±1 dB from dc to 5 MHz, usable up to 8 MHz. Horizontal sweep frequency adjustable up to 1 MHz in 6 ranges, permitting lock-in of signals up to 10 MHz. Level of sync signal adjustable. Pre-set TV vertical (V) and horizontal (H) sweep positions. Complete with *WG-400A* direct/low capaci-

tance probe and cable, alligator clip and instructions. $298.50—Commercial Engineering, RCA Electronic Components, Harrison, N. J. 07029.

Circle 42 on reader service card

COMING NEXT MONTH

R-E's Annual Color TV Issue! A special number crammed full of up-to-date information from your favorite authors. They bring you articles on new color TV circuits, selecting and using test instruments for color servicing and the last word on modern servicing techniques.

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 88 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

1970-71 CATALOG OF B & K PROFESSIONAL TEST EQUIPMENT—*BK-71*, for electronic servicing, school, laboratory, and industrial application. Solid-state design is dominant in the instruments, including an FET VOM, rf signal generator, Sine/square wave generator, and a tube tester. The Television Analyst, with solid-state sweep drive, which checks every stage of all color and b-w TV sets, is also included. Large illustrations, patterns and charts with details and specifications accompany items. Also included are a sweep/mark generator, oscilloscope/vectorscope, CRT rejuvenator checker, probes, adapters, and other accessories. 24 pages.—**Dynascan Corp.**, 1801 W. Belle Plaine Ave., Chicago, Ill. 60613.

Circle 43 on reader service card

CONVERSION CHART, wind pressure to wind velocity. Wind velocity is given in miles per hour, kilometers per hour and knots; wind pressure in pounds/sq. ft. A comprehensive checklist for engineering considerations in the purchase and installation of a microwave tower is provided, as well as guidelines for writing tower specifications. Wind velocity, icing, and rigidity as they apply to microwave tower specifications are also described.—**Microflect Co., Inc.**, 3575 25th St. S.E., Salem, Oregon 97302.

Circle 44 on reader service card

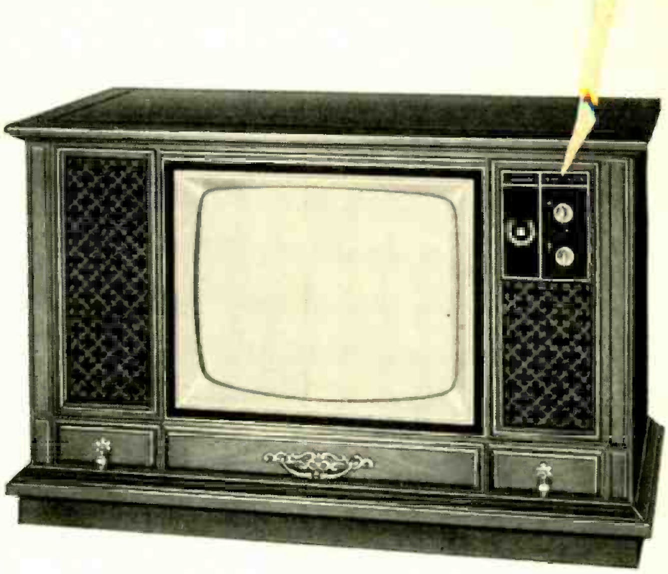
ANNUAL INDEX
(continued from page 68)

ANNUAL INDEX
(continued from page 74)

(continued on page 85)

New from Heath...in time

New Heathkit® solid-state modular color TV

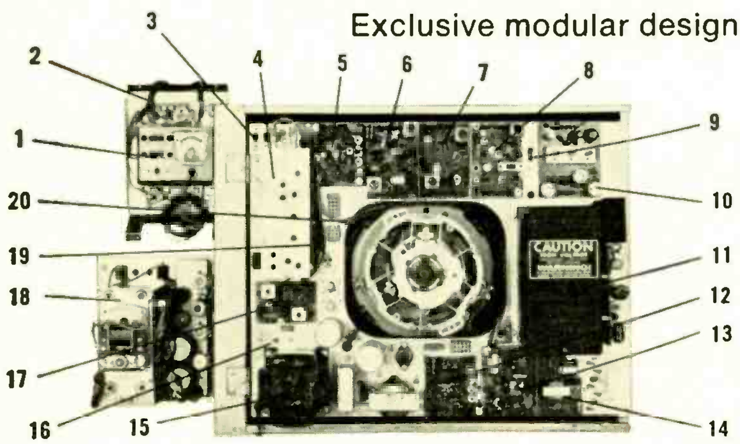


The result of over five years in research and development, these sets represent one of today's greatest color TV values. Here's why: a total of 45 transistors, 55 diodes, 2 silicon controlled rectifiers, 4 IC's containing another 46 transistors and 21 diodes plus 2 tubes (picture and high voltage rectifier) combine to deliver performance and reliability unequalled by any conventional tube set. Other features include: MOSFET VHF tuner; high-gain 3-stage solid-state IF; emitter-follower output; automatic fine tuning; VHF power tuning; built-in degaussing plus manual degaussing coil; automatic chroma control; adjustable noise limiting and gated AGC; "instant-on"... sound instantly, picture in seconds; bonded-face, etched glass picture tubes; adjustable tone control; exclusive hi-fi outputs; and 48-hour factory service facility for modules. The sets are designed to be owner-serviced ... the only sets on the market with this exclusive feature. A built-in dot generator, volt-ohm meter, and modular snap-out epoxy circuit boards make routine adjustments and service a snap ... virtually eliminating service calls and offering significant savings over the life of the set. It all adds up to the color TV buy of a lifetime in the GR-270 and GR-370 ... ready now for Christmas giving!

Kit **GR-270,** 227" 20V tube, 114 lbs. **$489.95***
Kit **GR-370,** 295" 23V tube, 127 lbs. **$559.95***
Kit **GR-370MX, GR-370** with RCA matrix tube, 127 lbs. **$569.95***

- Modular plug-in circuit board construction
- MOSFET VHF tuner and 3-stage IF
- Pushbutton channel advance
- Hi-fi sound outputs — for amplifier
- Designed for owner-servicing

Exclusive modular design



1 Exclusive check-out meter
2 Tilt-out convergence/secondary control panel
3 Gun shorting switches
4 3-stage IF assembly
5 Plug-in AGC/Sync circuit board
6 Plug-in 3.58 MHz oscillator circuit board
7 Plug-in Chroma circuit board
8 Plug-in Luminance circuit board
9 Service and Dots switches
10 Plug-in Video Output circuit board
11 High voltage power supply
12 Plug-in Vertical Oscillator circuit board
13 Plug-in Horizontal Oscillator circuit board
14 Plug-in Pincushion circuit board
15 Conservatively-rated power supply components
16 Circuit breaker protection
17 Plug-in Sound circuit board
18 Master control panel
19 Hi-fi sound output
20 Plug-in wiring harnesses and connectors for faster assembly

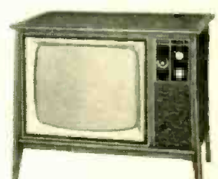
Choice of factory-assembled cabinets

3 models in 295 sq. in.

Luxurious Mediterranean Cabinet...factory assembled of fine furniture grade hardwoods and finished in a flawless Mediterranean pecan. Statuary bronze trim handle. 30-½" H x 47" W x 17¾" D. **Assembled GRA-304-23,** 78 lbs. **$129.95***

Deluxe Early American Cabinet...factory assembled of hardwoods & veneers and finished in classic Salem Maple. 29 21/32" H x 37¼" W x 19¾" D. **Assembled GRA-303-23,** 73 lbs. **$114.95***

Contemporary Walnut Cabinet...factory assembled of fine veneers & solids with an oil-rubbed walnut finish. 29 17/32" H x 35 13/16" W x 19⅞" D. **Assembled GRA-301-23,** 60 lbs. **$74.95***



3 models in 227 sq. in.

Exciting Mediterranean Cabinet...assembled using fine furniture techniques and finished in stylish Mediterranean pecan. Accented with statuary bronze handle. 27 31/32" H x 41⅞" W x 19 9/16" D. **Assembled GRA-202-20,** 85 lbs. **$114.95***

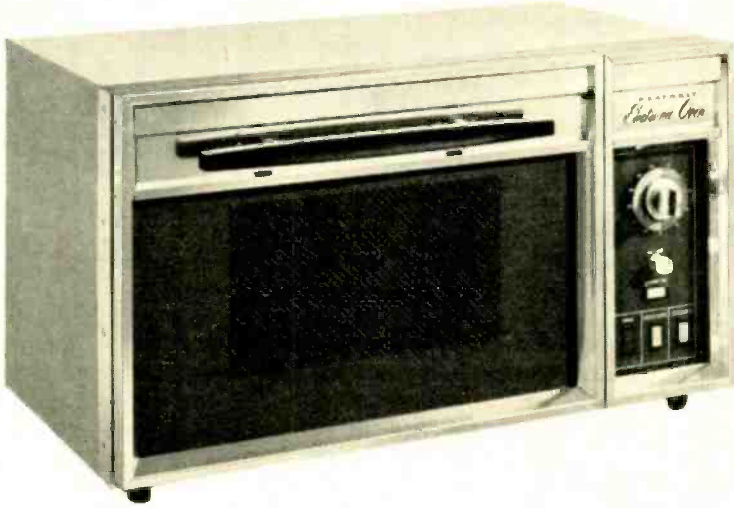
Contemporary Walnut Cabinet and Base Combination. Handsome walnut finished cabinet sits on a matching walnut base. Cabinet dimensions 20 21/32" H x 31 7/16" W x 18⅝" D. Base dimensions 7¾" H x 27¾" W x 18⅝" D. **Assembled GRA-203-20 Cabinet,** 46 lbs. **$49.95*** **GRS-203-6 above cab. w/matching base,** 59 lbs. **$59.95***

Handy Roll-Around Cart and Cabinet Combination. Features the GRA-203-20 walnut cabinet plus a walnut-trimmed wheeled cart with storage shelf. **Assembled GRA-203-20 Cabinet,** 46 lbs. **$49.95*** **GRA-204-20 Roll-Around Cart,** 19 lbs. .. **$19.95*** **GRS-203-5 Cart & Cabinet Combo,** 65 lbs. **$59.95***

for Christmas giving

New Heathkit Electronic Oven

...only $399.95*

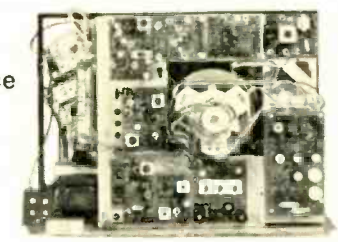


Now, through the miracle of microwave energy, a cooking revolution that frees you from conventional kitchen drudgery forever!

Imagine a baked potato in 4 minutes; baked beans in a little over 6 minutes; a five-pound roast in 45 minutes. This is the miracle of microwave cooking. And now Heath brings you this modern miracle for the first time in money-saving, easy-to-assemble kit form. For busy families on the go, meal preparation is a matter of minutes. You can cook on china, glass, or even paper dishes since only the food becomes hot. Your cooking dish can be your serving dish. Frozen foods can be defrosted in minutes for quick spur-of-the-moment frozen meals cooked right in their own containers. And there is not the slightest cause for concern about the safety of your Heathkit electronic oven. Exclusive door design prevents microwave leakage from the oven cavity. And with a SAFETY INTERLOCK SYSTEM UNIQUE IN THE INDUSTRY, not only does the oven stop cooking if the door is opened, but the door can't be opened unless the interlock is operating properly. A second independent door interlock is also provided for maximum protection. And all interlock mechanisms are tamperproof. Assembled in accordance with the manual, the GD-29 meets all the new federal standards for safety and radio interference. No special precautions are required when operating. The Heathkit electronic oven is as safe as your conventional oven! Quality components are used throughout: magnetron tube by Litton, the uncontested leader in the field; avalanche diode circuitry for longer tube life; simplified wiring harness with push-on quick-connectors for reliability and ease of assembly. GD-29 prototypes endured grueling "life-tests" equivalent to over 60 years of continuous service... further assurance of uncompromised reliability. Another feature is portability: the Heathkit electronic oven operates on regular household current. Plug it in anywhere... on a countertop, a wheeled cart, in the kitchen, on the patio, at the cottage... anyplace a grounded 120V AC power outlet is available. Make this a Christmas to remember by putting a Heathkit electronic oven under the tree. It's a gift your wife will thrill to... and a present the whole family will enjoy... meal after meal after meal.

Kit **GD-29,** 80 lbs. **$399.95***

New Heathkit portable solid-state color TV

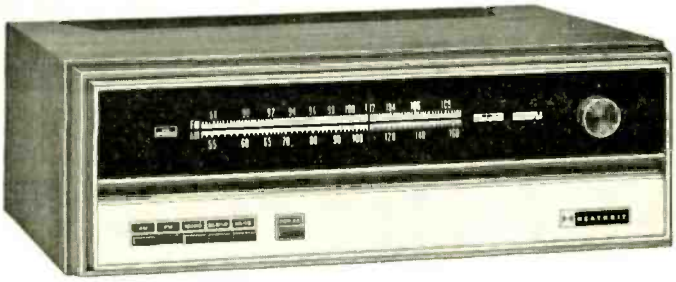


- Big set performance, portable convenience
- MOSFET VHF tuner & 3-stage IF
- Modular, self-service design
- 102″, 14 V picture tube

What do you do for an encore after you've created the solid-state GR-270 and GR-370 big-screen sets? Simple. Make them portable. That's virtually what's been done in the new Heathkit GR-169 solid-state portable color TV. Heath engineers took the same cool-running solid-state circuitry from the large screen chassis and packaged it in an easy-to-assemble compact chassis... with the same nine plug-in glass epoxy circuit board modules used in the big sets. In fact the only difference is the smaller preassembled horizontal deflection and high voltage power supply. The same MOSFET tuner and high gain 3-stage IF found in the big sets offer superlative color performance. And, as in the larger sets, complete owner service features are provided by inclusion of built-in dot generator and degaussing along with an exclusive volt-ohm check-out meter. 48-hour factory service facilities for modules are also provided with the GR-169. Other features include: built-in antennas and connections for external antennas; instant picture and sound; complete secondary controls available behind the hinged door on the front panel; high resolution circuitry for sharp, crisp pictures; adjustable noise limiting to keep external interference to a minimum. If you're looking for big set color fidelity and performance with portable convenience... put the new Heathkit GR-169 on your Christmas shopping list now!

Kit **GR-169,** 48 lbs. **$349.95***

New Heath-gift ideas... for



New Heathkit® AJ-29 AM-FM-FM stereo tuner

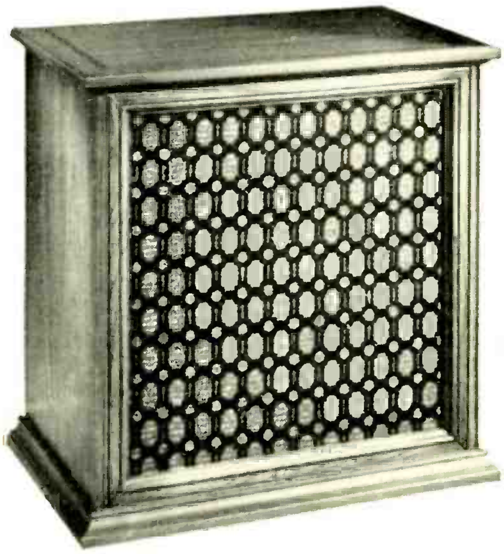
This is the feature-packed tuner section of the famous Heathkit AR-29 stereo receiver . . . now available as a stereo "separate." The pre-assembled, factory-aligned FM tuner boasts 1.8 uV sensitivity for whopping station pulling power using FET design for superior overload characteristics. Three IC's in the IF section offer superior AM rejection, hard limiting, temperature stability, and outstanding reliability. Other features include a computer-designed 9-pole L-C filter for greater than 70 dB selectivity; new "blend" and "mute" functions; and a built-in AM rod antenna that swivels for best reception.

Kit **AJ-29,** 19 lbs., less cabinet **$169.95***
Assembled **AE-19,** oiled pecan cab., 9 lbs. **$19.95***

New Heathkit® AA-29 100-watt stereo amplifier

Power-packed amplifier section of the Heathkit AR-29, the AA-29 stereo "separate" marks another milestone in superior Heathkit amplifier design. Its 70-watts of continuous power is more than enough to drive even the most inefficient speaker systems. A massive, fully-regulated and filtered power supply, 4 conservatively heat sinked output transistors and the best IM and harmonic distortion specifications in the industry add up to sound fidelity you never expected to hear outside the theater. Modular plug-in circuit boards make assembly easier . . . snap out in seconds for future servicing.

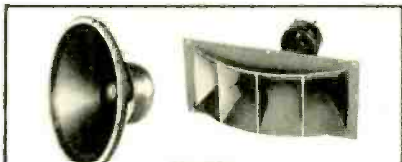
Kit **AA-29,** 27 lbs., less cabinet **$149.95***
Assembled **AE-19,** oiled pecan cab., 9 lbs. **$19.95***



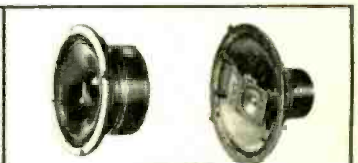
New Heathkit® floor model speaker systems

In the new Heathkit AS-101 and AS-102 speaker systems, Heath engineers have combined the best of both worlds of sound and beauty. The AS-101 Heath/Altec-Lansing 2-way system features a 15" woofer and sectoral horn delivering from 35 to 22,000 Hz with uncompromising accuracy. The AS-102 Heath/Bozak 3-way system uses a 12" woofer, 6" mid-range, and two 2½" tweeters in an infinite baffle design to produce clean natural reproduction from 40 to 20,000 Hz. Both systems are housed in assembled Mediterranean pecan cabinets, 29⅝" H x 27¾" W x 19⅞" D.

Kit **AS-101,** 53 lbs. **$259.95***
Kit **AS-102,** 39 lbs. **$259.95***

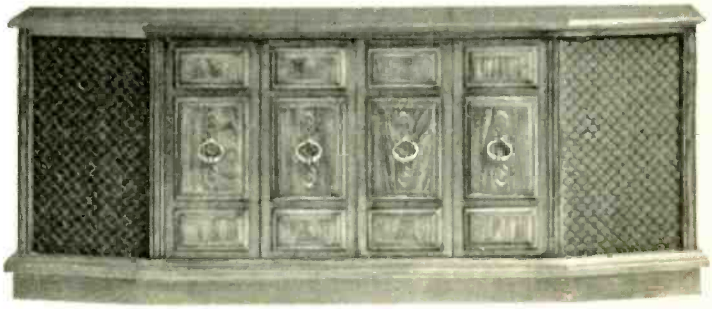


AS-101



AS-102

New Heath stereo equipment credenza



Romantic Mediterranean styling in wife-pleasing one-piece console design . . . yet with plenty of room for your favorite separate stereo components. Six-and-a-half feet of solid craftsmanship executed in North American Hickory veneers and solid oak trim, finished in oiled pecan. Completely assembled and finished, ready for installation of Heath or other components. Speaker enclosures are ducted port reflex design, pre-cut for 12" speakers. An adjustable shelf has room for stereo receiver, cartridge or cassette tape player or separate tuner and amplifier. Below the shelf is room for your turntable and record storage. Accessory matching drawers on ball bearing slides are available for turntable and tape player.

Model **AE-101,** 90 lbs. **$189.95***

home, shop and ham shack

New Heathkit® IC 15 MHz frequency counter...199.95*

A highly accurate, low cost frequency meter for anyone requiring accurate frequency measurements. Compare these features to counters selling for over twice this low price: accurate counting, 1 Hz to over 15 MHz; integrated circuitry; automatic trigger level for wide range input without adjustment; five digit readout with Hz/kHz ranges and overrange indicators for eight digit capability; high input impedance; storage circuitry for non-blinking, no-count-up readout; computer-type circuitry, no divider chain adjustment; temperature-compensated crystal time base oscillator; BNC input with cable; double-sided, plated-thru circuit board with sockets; three-wire, removable line cord; heavy-duty aluminum case handle/tilt stand and die cast zinc front panel; no special instruments required for accurate calibration.

Kit **IB-101**, 7 lbs. **$199.95***

IB-101 SPECIFICATIONS: Frequency Range: 1 Hz to greater than 15 MHz. **Accuracy:** ±1 count ± time base stability. **Gate Times:** 1 millisecond or 1 second with automatic reset. **Input Characteristics: Sensitivity:** 1 Hz to 1 MHz, less than 100 mV rms. 1 MHz to 15 MHz, less than 250 mV rms. After 30 minutes warmup. **Trigger Level:** Automatic. **Impedance:** 1 Meg ohm shunted by less than 20 pf. **Maximum Input:** 200 V rms, DC–1 kHz. Derate at 48 V per frequency decade. **TIME BASE: Frequency:** 1 MHz, crystal controlled. **Aging Rate:** Less than 1 PPM/month after 30 days. **Temperature:** Less than ±2 parts in 10^7/degree C. 20 to 35 degrees C after 30 minutes warmup. ±.002% from 0 to 50 degrees C. **GENERAL: Readout:** 5 digits plus overrange. **Temperature Range:** Storage; —55 to 80 degrees C. Operating; 0 to 50 degrees C. **Power Requirements:** 105-125 or 210-250 VAC, 50/60 Hz, 8 watts. **Cabinet Dimensions:** 8¼" W x 3⅛" H x 9" D not including handle. **Net Weight:** 4½ lbs.

See these and 300 other Heath-gift suggestions at one of the following Heathkit Electronic Centers:

Anaheim, Calif. 92805
330 E. Ball Road

Boston Area
Wellesley, Mass. 02181
165 Worcester St.

Chicago, Illinois 60645
3462-66 W. Devon Ave.

Chicago Area
Downers Grove, Ill. 60515
224 Ogden Avenue

Cleveland, Ohio 44129
5444 Pearl Road

Dallas, Texas 75201
2715 Ross Avenue

Denver, Colorado 80212
5940 W. 38th Ave.

Detroit, Michigan 48219
18645 W. 8 Mile Road

Fair Lawn, N. J. 07410
35-07 Broadway (Rt. 4)

Houston, Texas 77027
3705 Westheimer

Los Angeles, Calif. 90007
2309 S. Flower St.

Milwaukee, Wisc. 53216
5215 W. Fond du Lac

Minneapolis Area
Hopkins, Minn. 55343
101 Shady Oak Road

New York, N.Y. 10036
35 W. 45th Street

Philadelphia, Pa. 19149
6318 Roosevelt Blvd.

Pittsburgh, Pa. 15235
3482 William Penn Highway

St. Louis, Mo. 63123
9296 Gravois Ave.

San Diego Area
LaMesa, Calif. 92041
8363 Center Drive

San Francisco Area
Redwood City, Calif. 94063
2001 Middlefield Road

Seattle, Wash. 98121
2221 Third Avenue

Washington, D. C. Area
Rockville, Md. 20852
5542 Nicholson Lane

All Heathkit Electronic Centers are units of Schlumberger Products Corporation.
Heathkit Electronic Center Prices Slightly Higher.

During 1971, consult Heathkit Catalog Supplements and local newspapers for announcements of new Heathkit Electronic Centers opening in these places:

Long Island Area
Westbury, New York

Miami, Florida

San Francisco Area
El Cerrito, California

Cincinnati, Ohio

Los Angeles Area
Woodland Hills, California

Atlanta, Georgia

Prices listed are factory mail order.
Retail prices are slightly higher.

... or send for your FREE factory mail order catalog

New Heathkit® HW-101 SSB transceiver

The Hams at Heath have done it again . . . with an uprated version of the Heathkit HW-100, one of the most popular pieces of ham gear on the market! The HW-101 features improved receiver circuitry resulting in better than 0.35 uV sensitivity for 10 dB S+N/N. Image and IF rejection are better than 50 dB. Other improvements are a new 36-to-1 ball-bearing dial drive; new selectable SSB or CW filters and attractive new front-panel styling.

Kit **HW-101**, 23 lbs. **$249.95***

New Heathkit wattmeter/SWR bridge

Two switch-selected ranges allow measurement of RF output from 10-200 W and 100-2000 W. Built-in calibrator permits 10% accuracy throughout the 80-10 M ham bands.

Kit **HM-102**, 3 lbs. **$29.95***

HEATHKIT
a Schlumberger Company

HEATH COMPANY, Dept. 20-12
Benton Harbor, Michigan 49022

☐ Enclosed is $__________, plus shipping.

Please send model (s) __________

☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

Name __________

Address __________

City __________ State __________ Zip __________

*Mail order prices; F.O.B. factory.
Prices & specifications subject to change without notice. CL-394

Circle 68 on reader service card

TRY THIS ONE

OUTLET TESTER

At times, the TV that your customer says is dead or operates intermittently in his home, suffers from a poor electrical outlet or a blown fuse.

Our method of checking before we pull the back off the TV set is with a cheater cord to which we have wired a neon bulb. The moment we plug the cord into the customer's outlet, we know if there's juice there. Then we pull off the back of the set and use the cord as a conventional cheater. In working on the set, by keeping a watchful eye on the neon bulb indicator, you can tell by its flickering if the outlet is the intermittent and not the set.—*Harry J. Miller*

LABEL REELS—AND THE TAPE ITSELF

To label the contents of a reel or tape easily, stick masking tape on the spokes of the reel and write on them with a felt-tip marking pen. Be sure to date the reels on the labels. Announce any program to be saved, indicating equipment used, the time, the place, the performers and other pertinent data. The acoustics of a closed, parked car are excellent, by the way, for making professional-sounding announcements. To make note of programs as you go along, use a child's magic slate and tab the starting and stopping points on the tape by using bits of paper between layers on the reel, like book marks.—*Glen F. Stillwell*

DON'T LOSE SMALL PARTS

Whenever I work on transistor radios and other equipment that uses small screws and nuts, I stick the small hardware items to a short strip of adhesive tape to insure against loss

or misplacement. Cellophane tape also works but the hardware stands out better on the white tape.—*Robert E. Kelland*

IN THE SHOP
(continued from page 24)

the visible symptoms. From this we can eliminate quite a few things, because of their patent impossibility. For instance, if we see a bright, blank raster, we do not check the dc power supply, horizontal sweep, or the high voltage. We know they're ok.

The difference between the "Imagineer" and the plodder is like the difference between a rifle and a shotgun. **R-E**

Service Clinic

By JACK DARR
SERVICE EDITOR

Rf Interference In Bass Amplifier

I added a 50-watt bass amplifier with a big woofer to my stereo system. The stereo works fine, but I can hear radio signals from a local station in the woofer speaker. This speaker is supposed to have a top response of 300 Hz and handle signals only from 100 Hz down, but the radio signal sounds good. Can't get rid of this interference.—M. M., Los Angeles, Calif.

Filter! The radio signals are getting into the input of the bass-amplifier and are being detected in the grid or base circuit of the first amplifier stage. From here on they're audio, and they go right on through. (Evidently your crossover is *ahead* of this point in the system.)

You can get rid of the rf by a combination of shunt bypass capacitors or series rf chokes, or both.

Substitute For 29KQ6 Tube

I have a problem. Arvin and Panasonic are using a 29KQ6 horizontal output tube in some sets. This tube is almost impossible to get and is very high priced, even in this metropolitan area. Do you know of a practical substitute?—W. H., Bethayres, Pa.

I believe a 27GB5 looks closest, although the base connections would have to be rearranged. A 33JV6 is close, but it has 12-pin base and would need a new socket.

Agc/Sync Trouble, CTC 38

I've run into an odd trouble in a CTC38 RCA chassis. The horizontal sync doesn't have the range it ought to and once in a while it loses vertical sync too. Adjusting the agc control in either direction causes a loss of horizontal sync. The picture looks fairly good, but has a sort of "glitter" on *strong channels.—W. M., Phoenix, Ariz.*

Try new 6GH8's in the agc and sync-separator sockets. This will get the 1st and 2nd video amplifier stages at the same time. The video signal for the sync separator is taken off at the plate of the 2nd video amplifier, and the Y signal comes from its cathode. Anything wrong around either of these tubes could cause sync clipping.

On the scope, you should see an 80-volt p-p signal at this point consisting almost entirely of *sync*. The video should be compressed to a thick white line at the bottom. If this is reversed, you have trouble.

On the "glitter," this is probably what RCA used to call "busy background" a while back. Check the setting of the i.f. agc control, and the rf agc control.

Focus Resistor Changes Value

The focus goes off in an Admiral 3C341C chassis. I can readjust the focus pot and bring it back temporarily. Focus voltage supply is normal, about 5,500 volts at the focus-rectifier. I found that the 47-megohm resistor was changing from 47 megs to about 80 megohms when it got hot. I replaced it and the new one did the same thing! The 1.8-megohm resistor and the focus pot are ok.

Any ideas? Is this due to X-rays from the regulator tube? It's right by it.—A.F., Alexandria, Va.

Try replacing this with an IRC resistor of the film type. We haven't had any trouble with these. As to X-rays, I doubt it *very* much! The regulator tube in this set is supposed to have leaded glass in the bulb to prevent any radiation. In any case, radiation wouldn't be that high!

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 200 Park Ave. South, New York 10003.

(continued on page 85)

COMING NEXT MONTH

The Annual Color TV Issue brings you Belt, Darr, Lemons, Margolis and a bevy of your other favorite authors with up-to-the-minute dope on color TV circuits, test equipment and techniques.

MARKET CENTER

ELECTRONICS

B & K, Sencor test equipment, discount prices, Free catalog and price sheet. FORDHAM RADIO, 265 East 149th Street, Bronx, NY 10451

TUBE Sale to 80% off. Javelin ES 101 CCtv distributors net $350.00. Mail order only. **J. KNIGHT TV,** 612 Gaines Avenue, Hot Springs, Ark. 71901

DISCHARGE Ignition, Photoflash. Free catalog parts, kits. **TRANSPARK,** Carlisle, Mass. 01741

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans $2.00. **RELCO**-A25, Box 10563, Houston, Texas 77018

INDUSTRIAL and Government Electronic Surplus. Monthly catalog lists—all different! **STARTRONICS,** Box 17127, Portland, Oregon 97217

RADIO and TV Tubes 36¢ each. One year guaranteed. Plus many unusual electronic bargains. Free Catalog. **CORNELL** 4217-E University, San Diego, California 92105

INTEGRATED Circuit Kits-Free catalog. **FRAZER & ASSOCIATES,** 3809 Surfwood Road, Malibu, Calif. 90265

TUBES—Lowest prices. Foreign-American. Obsolete, receiving, special purpose, transmitting tubes. Send for tube, parts catalog. **UNITED RADIO COMPANY,** 56-R Ferry St., Newark, N.J. 07105

RECEIVING & Industrial Tubes, Transistors. All Brands—Biggest Discounts. Technicians, Hobbyists, Experimenters—Request FREE Giant Catalog and SAVE! **ZALYTRON,** 469 Jericho Turnpike, Mineola, N.Y. 11501

AUDIO—HI-FI

TAPEMATES makes available to you ALL 4-TRACK STEREO TAPES. ALL labels—Postpaid to your door—at tremendous savings. For free brochure write: **TAPEMATES CLUB,** 5280 RE West Pico Blvd., Los Angeles, Calif. 90019

TRADE A TAPE. Got an 8-track cartridge or 4-track cassette you're tired of listening to? Send it to me, with $2 and I'll send you another tape to replace it—music in a similar vein, of course. Special! New 4-track tapes $1.50 each. List 25¢, refundable. **WARREN ROY,** 24 Straw Lane, Hicksville, NY 11801

RENT 4-track open reel tapes—all major labels—3,000 different—free brochure. **STERIO-PARTI,** 55 St. James Drive, Santa Rosa, Calif. 95401

741P TEXAS INSTRUMENT OPERATIONAL AMPLIFIERS—$2.00 plus postage. **BALL ELECTRONICS,** Box 68, South Willington, Conn. 06265

UNSATISFACTORY "live" recordings? Inexpensive new products for improved microphone fidelity and flexibility are available. Write **RUSSOUND, Inc.** Dept. 3, Box 1015, Framingham, Mass. 01701

DECODERS! COUNTERS! LATCHES! MEMORIES! IC's

NATIONAL DYNAMIC SHIFT REGISTERS

Any 3 — 10% Discount!

Type	Description	Sale
☐ MM-500	Dual 25 Bit	$3.95
☐ MM-502	Dual 50 Bit	5.95

Both TO-5 Cases

COUNTING SYSTEM

3 PC. KIT

$10

Includes SN7490 decade counter, SN7441 BCD decoder-driver, SN7475 quad latch with hookups, instructions

FAIRCHILD IC "AMP"

Any 3 10% Discount!

Type	Description	Each
☐ 702	Wide Band DC	1.49
☐ 703	RF-IF Amp	1.25
☐ 709	Operational Amp	1.49
☐ 710	Hi-Speed Diff	1.19
☐ 711	Dual Comparator	1.49
☐ 741	Freq. Comp. 709	2.50

GIANT SALE ON NEW TTL TEXAS & NATIONAL ICs

Guaranteed! W/Spec Sheets
Any 3 — 10% Discount!

Type	Description	SALE
☐ SN7400N	Quad 2 Input Nand Gate	$ .88
☐ SN7402N	Quad 2 Input NOR Gate	.88
☐ SN7404N	Hex Inverter	.99
☐ SN7410N	Triple 3 In. NAND Gate	.88
☐ SN7420N	Dual 4 In. NAND Gate	.88
☐ SN7430N	8 Input NAND Gate	.88
☐ SN7440N	Dual 4 In. Nand BUFFER	.88
☐ SN7440F	Dual 4 In. Nand BUFFER	.88
☐ SN7441N	BCD to Decimal Driver	4.95
☐ SN7442N	BCD to Decimal Decoder	4.50
☐ SN7470F	J-K Flip Flop	.99
☐ SN7472N	J-K Master Slave Flip Flop	1.19
☐ SN7473N	Dual J-K Master Slave Flip-Flop	1.49
☐ SN7474N	Dual "D" Type Edge Triggered Flip Flop	1.49
☐ SN7475N	4 Bit Bistable Latch	2.95
☐ SN7476N	Dual J-K Master Slave Flip Flop	1.49
☐ SN7483N	4 Bit Binary Full Adder	4.50
☐ SN7490N	Decade Counter	3.98
☐ SN7492N	Divide-by-twelve Counter	4.50
☐ SN7493N	4 Bit Binary (divide by 16)	3.98
☐ SN7495N	4 Bit Right & Left Register	4.50

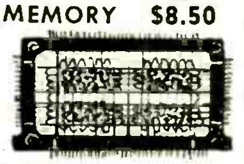
Code: F — Flat Pak, N — Dual Inline

SPRAGUE- IC's

Your Choice
3 for $1

Type	Description
☐ 908	Full Adder
☐ 909	Buffer
☐ 912	Half Adder
☐ 913	Shift Register
☐ 921	Dual 2 In. Gate
☐ 940	JK Flip Flop
☐ 960	Dual Buffer

4,000 BIT MEMORY $8.50 ☐



From IBM Computers, Guaranteed! W/Spec Sheets

FAIRCHILD IC SALE

Guaranteed! W/Spec Sheets
Any 3 — 10% Discount! * = TO-5 case. N = dual inline;

Type	Description	Sale
☐ 914*	Quad 2 Input Gate	$ .99
☐ 915*	Dual 3 In. Gate	.77
☐ 923*	J-K Flip Flop	.99
☐ 958N*	Decade Counter	3.95
☐ 959N*	Quad Bistable Latch	2.95
☐ 1128*	8 Bit Memory	2.49
☐ 9033N	16 Bit Memory	3.95
☐ 9601N	Triggerable Monostable Vibrator	4.95
☐ 9300N	4 Bit Shift Reg.	2.49
☐ 9301N	1 of 10 Decoder	3.95
☐ 9304N	Dual Full Adder	3.95

☐ 10¢ Catalog on Fiber Optics, 'ICs', Semis, Parts

FALL-CHRISTMAS LINE-LITERS

☐ 2—N CHANNEL plastic Fets 2N3819 Texas	$1.19
☐ 2—UNIJUNCTION transistors 2N4891	$1.19
☐ 1—IG MOS FET P channel 2N4353	$1.00
☐ 3—TRIGGER diodes for Scrs, Triacs	$1.00
☐ 1—15-AMP Triac 200 PRV	$1.49

Terms: add postage. **Rated:** net 30. cod's 25%.
Phone Orders: Wakefield, Mass. (617) 245-3829
Retail: 211 Albion, St., Wakefield, Mass.

POLY PAKS P.O. BOX 942 R LYNNFIELD, MASS 01940

Circle 82 on reader service card

ADVERTISING INDEX

RADIO-ELECTRONICS does not assume responsibility for any errors which may appear in the index below.

STEREO TAPE TRANSPORT—7" reel—2 speeds—pause control—made for famous manufacturer—50 to 15,000 Hz—with rec/play and erase heads, without case. Send M.O. or check for $19.50 to **STEREO CENTER**, 218 Columbia St., Utica, N.Y. 13502. $2.50 for prepaid shipping and insurance.

NEW BSR record changers; $13.00. McDonald 300-18.00; 400-$20.00; 500-$25.00; AM/FM component system-$50.00. **DAVIS**, Dept. RE, 2737 Third Ave., Bronx, N.Y. 10451

SAVE over 331/3 on a pair of one of the World's Best Speaker Systems. Shipped Direct to you from factory. Try them in your home for thirty days. **KGLL, INC.** Water Street, Lewiston, Maine 04240

BACKGROUND MUSIC continuous, commercial-free. Solid-state MUSICON SCA ADAPTER plugs into any FM Tuner, Receiver. Line powered. 5 year guarantee! Only $39 postpaid. **K-LAB**, Box 572R, South Norwalk, Conn. 06856

CASSETTES CASH IN ON a tremendous All-year round market. Send for lowest pricing and details. Include $1.00 for 2 cassettes samples. **DICTATION PRODUCTS**, P.O. Box DPK, Hallandale, Fla. 33009

INVENTIONS & PATENTS

FREE "Directory of 500 Corporations Seeking New Products". For information regarding development, sale, licensing of your patented/unpatented invention. Write: **RAYMOND LEE ORGANIZATION**, 230-U Park Avenue, New York City 10017

INVENTIONS Wanted. Patented; Unpatented. **GLOBAL MARKETING**, 2420-AE 77th Ave., Oakland, Calif. 94605

Circle 83 on reader service card

ANNUAL INDEX
(continued from page 75)

SERVICE CLINIC
(continued from page 83)

Too Much Contrast, No Control

The picture in an RCA CTC31 got gradually darker; color, sound, etc. ok. Brightness control works, but contrast control doesn't seem to have much effect. Video peaking control has very little effect if any. Contrast control checks ok. Video output tube ok. Where is this?—H. T., Houstin, Tex.

The contrast control here is a "variable degeneration" type, like so many of them. What it actually does is move a big electrolytic cathode-bypass capacitor up and down on the cathode resistor. If this capacitor *opens*, your picture will be "pale," and the control will have no effect.

However, you have the opposite effect; *too much* contrast. Note that this circuit actually has three branches: the contrast control itself; a small fixed peaking network, 270 ohms and 680 pF in series; and the video peaking network. I have a distinct feeling that something is shorted in here.

If the electrolytic were shorted, the control would still show some effect. Therefore, the short is most apt to be "at the top of the control" or

(continued on page 87)

Circle 84 on reader service card

MARKET CENTER

INVENTORS: Protect your ideas! Free "Recommended Procedure". **WASHINGTON INVENTORS SERVICE.** 422X Washington Building, Washington, D.C. 20005

EDUCATION/ INSTRUCTION

"HOW TO INCREASE TRANSISTOR RADIO REPAIR PROFIT." Write: **X T R**, Box 1556, Las Vegas, Nev. 89101

MEMORIZE, Study: "1970 Test-Answers" for FCC First and Second Class License.—plus—"Self-Study Ability Test." Proven. $5.00. **COMMAND,** Box 26348-E, San Francisco, Calif. 94126

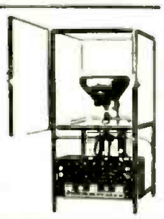
ELECTRONICS Engineering. Day or evening classes. Bachelor of Science Program evenings. Associate in Science Program day or night. If you are married or if you must work for a living while obtaining your education, this is the college for you. Approved for Veterans. **WESTERN STATES COLLEGE OF ENGINEERING,** 970 West Manchester Avenue, Inglewood, Calif. 90301

TV TUNER REPAIRS—Complete Course Details, 12 Repair Tricks, Many Plans, Two Lessons, all for $1. Refundable. **FRANK BOCEK,** Box 3236 (Enterprise), Redding, Calif. 96001

WANTED

CLASSICAL monaural unscratched records wanted. **JUNKER,** 326 Parnassus, San Francisco, Calif. 94117

QUICK CASH . . . for Electronic EQUIPMENT, COMPONENTS, unused TUBES. Send list now! **BARRY,** 512 Broadway, New York, N.Y. 10012, 212 WALKER 5-7000



GOVERNMENT SURPLUS

JEEPS Typically from $53.90 . . . Trucks From $78.40 . . . Boats, Typewriters, Airplanes, Multimeters, Oscilloscopes, Transceivers, Electronics Equipment. Wide Variety, Condition. 100,000 Bid Bargains Direct From Government Nationwide. Complete Sales Directory and Surplus Catalog $1.00 (Deductible First $10.00 Order). **SURPLUS SERVICE,** Box 820-REL, Holland, Michigan 49423

MANUALS for surplus electronics. List 25¢. **BOOKS,** 4905 Roanne Drive, Washington, D.C. 20021

GENERAL

TAPES of old radio shows for sale. Catalog 35¢ refundable. **ROBERT JOSEPH,** 1250 LaBaron, Webster, N.Y. 14580

JAPANESE NEW PRODUCTS MONTHLY! $1.00 Refundable. **DEERE,** 10639 Riverside, North Hollywood, Calif. 91602

PRECISION Hole Finder. It's New. $1.49 Post Paid. **PRECISION PRODUCTS,** 1261 Gamble Lane, Escondido, Calif. 92025

SCHOOL DIRECTORY

Help your Post Office to give you the best possible service —Mail early in the day! !

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION, Act of October 23, 1962, Section 4369, Title 39, United States Code.)

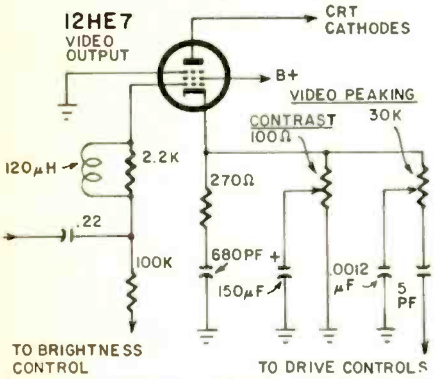
1. Date of filing: October 1, 1970
2. Title of publication: RADIO-ELECTRONICS
3. Frequency of issue: Monthly
4. Location of known office of publication: Ferry Street, Concord, Merrimack County, New Hampshire 03302.
5. Location of the headquarters or general business offices of the publishers: 200 Park Avenue South, New York, New York 10003.
6. Names and addresses of publisher, editor, and managing editor: Publisher. M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Editor M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Managing Editor, Larry Steckler, 200 Park Avenue South, New York, New York 10003.
7. Owner: Gernsback Publications, Inc., 200 Park Avenue South, New York, New York 10003; M. Harvey Gernsback, 200 Park Avenue South, New York, New York 10003; Mary H. Gernsback, M. Harvey Gernsback, Maurice Coyne, Benjamin E. Winston As Trustees Under Trust Agreement dated September 30, 1965, c/o Benjamin E. Winston, Esq., 2 W. 46th St., New York, New York.
8. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages or other securities: None.
9. For completion by nonprofit organizations authorized to mail at special rates: Does not apply in this case.
10. Extent and nature of circulation. Average number of copies each issue during preceding 12 months are: (A) Total No. of copies printed (net press run): 206.647; (B) Paid circulation: (1) Sales through dealers and carriers, street vendors and counter sales: 42,648; (2) Mail subscriptions: 106.849; (C) Total paid circulation: 149,497; (D) Free distribution (including samples) by mail, carrier or other means: 1,562; (E) Total distribution: 151,059; (F) Office use, left-over, unaccounted, spoiled after printing: 55,588; (G) Total: 206.647. The number of copies of single issue nearest to filing date: (A) Total number copies printed (net press run): 216,091; (B) Paid circulation. (1) Sales through dealers and carriers, street vendors and counter sales: 44,258; (2) Mail subscription: 106,156; (C) Total paid circulation: 150,414; (D) Free distribution (including samples) by mail, carrier or other means: 1,520; (E) Total distribution: 151,-934; (F) Office use, left-over, unaccounted, spoiled after printing: 64,157; (G) Total: 216,-091.

I certify that the statements made by me above are correct and complete.
(Signed) H. Matysko, Circulation Manager

SERVICE CLINIC

(continued from page 85)

the cathode itself. I believe that I'd suspect a short in the 680-pF capacitor. It could be in the .0012-mF capacitor of the peaking network, but if it were, the video peak control would



have more effect. Also it would affect the contrast. Check dc resistance from cathode of the 12HG7 to ground. Normal reading is the 100-ohms of the contrast control. All other paths are normally blocked by capacitors. Disconnect these one at a time and you'll find it.

Pulsing Focus

My old color set works very well, since I put in a new picture tube and some others. However, I have an odd problem. The focus pulses in and out at about 2 cycles per second.—C.H., Port Angeles, Wash.

(We replied to this question giving some suggestions as to places for tests, etc., and in a little while the reader replied;)

"I found the focus trouble! Pin 2 of tht 6DW4 damper tube had a very poor socket contact! The contact was pushed so far down that the tube-pin was barely making contact with it. Pushing this up and fixing it made the focus work. Why?"

It's quite possible that the poor contact on the damper plate pin was letting the high voltage *and* focus voltage "pulse." When the damper current started to rise, it could go up until it got nearly to the peak value, then the high resistance of the poor contact either arced, or made the voltage drop.

Focus voltage must always be a certain *percentage* of the high voltage. It must "track" the HV; go up or down if the HV goes up or down, to maintain focus. If the boost voltage dropped very suddenly, this would reduce both focus and HV, since they come from a common source. The slightly larger *capacitance* in the HV circuit would tend to hold the HV up for a fraction of a millisecond longer than the focus voltage! So, they got out of step and you had the "pulsing" Phenomenon. **R-E**

CLASSIFIED COMMERCIAL RATE (for firms or individuals offering commercial products or services). 70¢ per word . . . minimum 10 words.
NON-COMMERCIAL RATE (for individuals who want to buy or sell personal items) 30¢ per word . . . no minimum.
FIRST WORD and NAME set in bold caps at no extra charge. Additional bold face at 10¢ per word. Payment must accompany all ads except those placed by accredited advertising agencies. 10% discount on 12 consecutive insertions, if paid in advance. Misleading or objectionable ads not accepted. Copy for February issue must reach us before Dec. 5.

CLASSIFIED ADVERTISING ORDER FORM

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25
26	27	28	29	30
31	32	33	34	35

________ No. of Words { @ .30 Non-Commercial Rates / @ .70 Commercial Rate } =$______

No. of Words in bold caps @ .10 =$______

Total Enclosed $______

Insert______time(s)

Starting with______issue

Payment must accompany order unless placed through accredited advertising agency 28

NAME______

ADDRESS______

CITY______STATE______ZIP______

SIGNATURE______

MAIL TO: RADIO-ELECTRONICS, CLASSIFIED AD DEPT., 200 PARK AVE. SOUTH, NEW YORK, N.Y. 10003

DESIGN FOR STEREO
(continued from page 40)

down voltage of the diode is reached. The voltage across the diode remains flat at 9 volts despite the fact that the peak voltage applied to the circuit rises to 17 volts. Below the 9 breakdown volts, the curve is identical in shape to the upper sinewave curve as applied to the circuit. This proves that the curve in Fig. 7 is proper, for up to V_B the diode is an open circuit and the entire input voltage is across the diode; above V_B the voltage remains relatively constant at V_B (9 volts in this case.) However, the reverse diode current increases rapidly above V_B.

The bottom half of the middle curve shows the effect of the forward characteristic of Fig. 2. Here, the voltage across the diode increases sinusoidally until V is reached. It remains at V (about 0.6 volts for silicon) until the applied sine wave signal once again falls below V. As for the reverse direction, in the forward direction this diode is an open circuit below V volts and is a relatively short circuit when the voltage applied to the circuit is above V.

The current flowing through the diode is identical to that flowing through the 1500-ohm resistor. The waveshapes of the voltage and current across a resistor are identical, so a scope across the resistor will display the current curve. If the scope is properly connected, you will observe the bottom curve in Fig. 9. Notice that in the first half of the curve, when the diode is reverse biased, no current flows until the breakdown voltage of the diode is exceeded. The current flowing through this portion of the cycle increases with the voltage applied to the circuit, due to cyclic variations. But note once again that in the middle drawing, the voltage across the diode remains at 9 volts despite the increase in current during this portion of the cycle.

In the forward direction, current flows practically through the entire cycle. (see the 180°–360° section of the lower drawing. This is because conduction starts at a low forward diode voltage, V. Once again, note in the middle drawing that the voltage across the diode will remain constant at V, regardless of the amount of current the diode is conducting.

In the next installment of this series, we will apply the solid-state diode to power supplies used in audio amplifiers. The diode will be used in several of the standard circuits. Methods for determining the ideal diode characteristic as well as procedures for calculating circuit components, will be detailed. **R-E**