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Circle 1 on reader service card

AUGUST 1973 • RADIO-ELECTRONICS 1
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As eye-catching as it is functional, the AU9500's elegant front-panel styling is a standout in any audio display. And it has two counterparts, the AU7500 and AU6500, which offer many of the same features, the same quality engineering and manufacturing, but slightly less power. All three are powerful, quality units that are unequalled for fine high fidelity reproduction.
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ANODE

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How VLP works

Eindhoven, Holland—The European electronics giant, Philips, has now moved its VLP (Video Long Play) color television disc system into the pre-production engineering stage, although it's not targeted for commercial introduction until the second half of 1975. Philips is in a competitive videodisc race with Teldec (German Telefunken and British Decca), MCA Disco-Vision (Universal Pictures), RCA and others.

At Philips' sprawling headquarters here, I saw a pressed 12-inch VLP disc and talked with Dr. K. Compaan, the scientist who is considered the father of the VLP. The disc itself looks like an art object—bright silver, emitting rainbow reflections when caught by the light. It is pressed in the conventional manner, then coated with a reflective material and a transparent protective coating.

As reported previously in this column, the disc revolves at 25 rps, one revolution being the equivalent of one television frame (the American version will spin at 30 rps, reflecting the difference in standards). The disc is scanned from the bottom by a laser beam, which is reflected back by a mirror. Looking at the disc, it is possible to discern a radial line running from the center to the outside. This is the vertical interval, or the space between TV frames. The reflective mirror itself assures tracking accuracy, while a servo keeps the pulses on the disc in focus.

One of the significant features of the system is that the picture jumps immediately into sync and stays in sync. The mirror is the integral component in retaining the synchronization as well as tracking, and permits slow motion, stop motion or even reverse action. A pulse is fed to the mirror during the vertical interval. For stop motion, this pulse instructs the mirror to continuously repeat the previous track. For slow motion, the mirror repeats each track once or more. For rapid motion, it skips one or more tracks every revolution. For reverse, it goes back to the preceding track. These instructions can be fed to the scanning mirror through controls on the record-playback machine or, in a more sophisticated version, through signals impressed on the disc itself in the vertical interval.

The current version of VLP plays for 30 minutes, scanning from the bottom of the disc, from the center to the outside, playing on one side only. Two-sided discs, and 45-minute discs, are also possible, according to Dr. Compaan. In its first version, the disc was to have used a standard high-intensity light, but Dr. Compaan said a breakthrough made possible a low-cost, mass-produced laser system. A by-product of this breakthrough will be reasonably priced lasers for many other applications.

Philips has no plans to make a disc changer, feeling that 30 minutes per disc is sufficient and perhaps the longest period anyone would want to view recorded video material without interruption. Polygram, a joint venture of Philips and Siemens (Germany), is currently developing consumer programming for the VLP, which is expected to be introduced simultaneously in Europe, the United States and Canada.

Other discs

I came away from my interview with Dr. Compaan with the feeling that Philips is seriously determined to be the leader in the video disc field, despite some allegations that Philips' activities constituted a defensive reaction to other efforts in this field, notably by Teldec.

The Teldec disc, using a mechanical pressure pickup, plays for 10 minutes in color, and achieves long-play status through means of a special disc-changing system it is expected to be demonstrated, and perhaps launched in the European consumer market, next month at the Berlin Radio-TV Show. We hope to be there, and report on this event in detail.

Among other video discs are two which use laser readout, placing them generally in the same classification as the Philips system. MCA Disco-Vision appears to be generally similar to Philips, and there have been reports of the beginning of discussions aimed at reaching compatibility between the two systems, but Philips calls these reports premature. The big leader in French electronics, Thomson-CSF, also is developing a laser disc system, about which little is currently known.

In the United States, Zenith has demonstrated what appears to be a variation on the Teldec mechanically-scanned system. RCA is known to have developed an electrostatic LP videodisc system which uses an electrically conductive coating on the disc and conductive stylus with an electrolytic layer in between, the varying capacitance producing video signals. Other video disc systems may also surface before long.

It's becoming clear that the video disc offers a promising method for low-cost home playback of pre-recorded color TV information. It now appears that everybody and his brother are working on new video disc systems. It's probable that only one system can be the winner.

Unlike the audio race which was compromised by the 33-45 player, it would be impractical to develop a device which could play different types of video discs—laser, mechanical and electrostatic.

TV film players

Several years ago, Sylvania introduced its Color Slide Theater, a combination color set and slide viewer, which made possible the showing of 35-mm color slides on the color TV screen. It seemed like a great idea, but the public just didn't take to it, so Sylvania shelved its plans for a followup—the Super-8 electronic movie viewer.

Last month we reported that Eastman Kodak plans to market this year a Super-8 attachment for playing home movies through the family color set. This system uses many of the principles developed jointly by Kodak and Sylvania. Now, others are getting into this act, too. Cassette Sciences says it will introduce a film videoplayer shortly. It will accommodate either Super-8 or 16-mm film with magnetic or optical sound.

Sign of the times

The first major American TV manufacturer to discontinue black-and-white set production entirely to concentrate on color is Warwick Electronics, which makes receivers for Sears Roebuck. The company's goal is to produce solid-state sets exclusively by the end of this year. It will add two new color TV sizes—15 and 17 inches—both using the newly developed slot-mask tube system with integral electron gun.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR
New electronics museum preserves radio history

Two unparalleled collections of electronics archives and artifacts form the basis for the new Foothills Electronics Museum, just opened to the public under the sponsorship of Foothills College, Los Altos Hills, near San Jose, California. Called a "hands-on" museum, only a vital few of its exhibits are shielded from handling by visitors. No admission fees are charged.

The Lee de Forest collection preserves some 2,500 photographs, models, personal documents, citations and awards, pertaining to the late Dr. de Forest. His widow, Marie de Forest, aided in identifying and cataloging the material. The second collection consists of several thousand artifacts from the radio pioneer Douglas Perham. It includes furnishings from "the world's first regularly scheduled broadcast station," started in San Jose in 1909 by C. D. Herrold, as a high-frequency spark radiophone. Known as FN originally, it was KQW from 1921 to 1949 and now operates in San Francisco as KCBS.

Besides the de Forest and Perham collections, the museum houses a number of other exhibits, including two amateur stations. One is an operating set-up, to show visitors what amateur radio is all about—the other a replica of a 1920 ham station.

Holographic computer memory uses laser, liquid crystals

An optical computer memory that can perform all the operations of a traditional computer memory—read, write, store and erase—has been demonstrated by scientists of the RCA laboratories at Princeton, N.J. The system, still in the early experimental stage, may be the forerunner of a new generation of mass memories with capacity equal to that of the largest present disc systems, but with a speed one hundred times as great.

The binary digits of the computer's two-word language are stored as holographic patterns of light and shade in a thermoplastic material. The holograms are produced in the material by a laser beam. On the way to the thermoplastic, the beam passes through a liquid crystal film, which is controlled electronically to be transparent to the laser light or to scatter it, according to whether the signal represents a "1" or a "0." This produces the patterns of light and shade in the holographic material. These can be read out again with a laser, as numbers composed of binary digits. Electro-acoustic deflectors direct the beam, both in reading and writing. The holograms can be erased at will, simply by applying heat to the thermoplastic storage material.

Bronx electronic technicians organize new association

A group of electronic technicians and shop owners of the Bronx, N.Y., met recently to discuss the formation of a new local association in their area. They invited two members of the Television Service Association (TSA) of Northeastern New York, a group headquartered in Albany, to answer questions. The president of TSA, Robert Plunz, and Warren Baker, CET, responded to the invitation and expressed themselves as well pleased with the turnout and the interest shown.

Some of the subjects covered at the meeting were the proposed registration of shops in New York State, and the alternative bill(s) to license the growing industry.

The group scheduled a second meeting, at Telefix, Inc., 862 Gerard Avenue, the Bronx, and arranged to publicize it more widely than the first. Interested parties were requested to contact Robert O'Casio of Telefix, phone 212-588-0884.

A NEW RADIO FIRE ALARM SYSTEM was credited with getting firefighters to this disastrous Lewiston, Maine, fire in time to keep life and property loss to a minimum. The radio alarm box, introduced by Gamewell in outlying regions, looks like a conventional "cottage" call box, but sends out a digitally coded nft signal, which sounds an alarm and actuates a printout at the fire station. The box transmits in the 72-78-MHz region between TV channels 4 and 5. It also has pushbuttons for police, medical aid and road service calls.

(continued on page 12)
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new & timely

(continued from page 6)

Snooper detects hidden fire

A recently patented piece of firefighting equipment spots hidden burning materials, such as hot coals between walls, by the radio waves emitted from the hot material. Operating between 8 and 9 GHz, the equipment is compact and light enough to be handheld and carried about. The signal becomes louder as the equipment is moved closer to the source of heat. Signals are picked up by a small parabolic antenna about the size of a saucer, and read on a meter mounted on top of the device. Prototype models of the detector have been built by the manufacturer, International Microwave Corp. of Cos Cob, Conn., and are being distributed to fire departments for testing.

Government frequency "need" perturbs uhf broadcasters

Uhf TV broadcasters are watching with a certain fearful interest a government move for more frequencies—presumably in the present uhf-TV band. The director of the Office of Telecommunications Policy has informed FCC Chairman Dean Burch that the government needs an additional 100 MHz "in the 100-to-1215 MHz band."

Since television broadcasting takes up the area between 174 and 216 MHz, and 470 to 890 MHz, the feeling that the government is looking at part of the spectrum allotted to TV broadcasting is strong, especially as other frequencies in the region carry important services that the government would not be disposed to bother.

The request has puzzled some in the FCC, because the government recently returned to the FCC for reallocation 26 MHz in the spectrum in which it is now asking four times the frequency space.

It was also pointed out that any needs claimed by the government would have to be examined very carefully, since in the past government agencies have not been famous for efficient use of spectrum space available to them.

Millimeter waves may open new communications spectrum

An experiment to test the feasibility of communication at super-high frequencies will be orbitied aboard NASA's ATS-F satellite in the spring of 1974. The experiment was designed by Hughes Aircraft Co. to test the feasibility of using this presently unexplored band of microwave frequencies, which could possibly provide a wide spectrum of "talking space" for future satellite systems.

SATELLITE'S SOLAR PANELS are larger than the ship. The two 4 x 8-foot panels, one of whose more than 11,000 solar cells is being inspected by RCA technician John Schelby, make the 10-foot-high NASA Nimbus-5 look like a butterfly. As a contrast to the widespread solar panels, RCA boasts of installing one of the most compact items on the ship as well, the High Data Rate storage system, which measures only 11 inches high, yet can record 30 million bits of data over a period of 120 minutes. By speeding up for playback, the meteorological and geophysical information is transmitted to ground stations in 5 minutes. Almost 300 watts of power is supplied by the solar cell system.

Cassette tapes introduced for electronics home study

A new system of teaching the basic principles and theories of electronics by correspondence, using pre-recorded cassette tapes, has been announced by RCA Institutes' director L. W. Snow. Studying with pre-recorded tapes is, according to Snow, the nearest thing to having an instructor guide the student through each lesson. The "instructor" (continued on page 14)
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The new 752-page manual, RC-29, includes technical data on more than 1400 RCA tube types. It also provides applications guides, terminal diagrams and replacement guides on entertainment and industrial receiving types as well as characteristics charts on picture tubes. In addition, there is a full section devoted to the use of RCA tubes in practical circuit applications.

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BRITISH AMATEUR ELECTRONICS CLUB

While we have nearly 250 members in this country and overseas, I am very disappointed that there are no girls, particularly as I know from articles and letters in electronic magazines that there are many who are interested in electronics as a hobby.

I would appreciate it if you would mention in your excellent magazine, which I am sure is read by many girls (of all ages) who are interested in electronics as a hobby, that if they would care to write to me at the above address, I would be only too pleased to send them details of the B.A.E.C. and also a copy of our Newsletter so that they can see the sort of things we do.

I would like to thank you for your interest and support of the B.A.E.C.

Cyril Bogod
26 Forrest Road, Penarth
Glam, Great Britain

WHAT WAVEFORM IS THAT?

In the article on the Modulated Function Generator in the July issue, you show a waveform (I) but do not describe it. What is it and how would I use it?

H. Harlee
Brentwood, N.Y.

The waveform is for an ultra-low-frequency AM signal. Its peculiar shape has made it useful in testing animal perception—as with porpoise and dolphins, earthquake simulation and certain types of oceanographic studies.

BETTER CLOCK GENERATOR

The clock generator circuit for the Digi-Designer shown on page 59 of the February issue of Radio-Electronics can be improved with three simple changes:

1. The output waveform has an on time of 45% and an off time of 55%. This is due to the capacitor being charged exponentially and discharged linearly. A symmetrical output can be obtained by adding a resistor, approximately 27,000 ohms, from the 5-volt supply to pin 2 of IC1. However, this will increase the frequency by approximately 10%.

2. IC1 pin 5 should be connected to ground when switch 1 is in the off position to prevent high-frequency oscillations.

3. The output waveform can be improved by using the unused gates in IC1 as buffer stages per attached sketch.

Robert G. Fleeger
Los Angeles, Calif.

NEW HEARING AID NOT NEW

With regard to the article on hearing through the teeth Radio-Electronics, June 1973, page 94), it may interest you to know that my grandfather used this method to tell if his watch was running. (He lost his hearing as a child.)

I saw him do this in 1925 and he had been doing this for some 30 or 40 years before then.

Some more information on medical electronics would be a welcome addition to your excellent publication.

R. H. Stockman
Morrison, Colo.

BOOLEAN BOBBLE

Please allow me to point out an error in the solution to a problem given in the article "Boolean Algebra And Computer Switching" by James F. Kennedy in the July 1973 issue of Radio-Electronics, on page 68, the circuit as follows is shown:

\[ A \land B \]

The solution as given in the article is:

1. Write the equation \( AB + AB = Y \)
2. Factor out A \( A(B + B) = Y \)
3. From a previous rule \( B + B = 1 \) (this is not sol)

The idempotent Law states: \( B + B = B \) NOT 1.

4. We should now continue:

\[ A(B + B) = Y \]
\[ A(B) = Y \]
\[ A = Y \]
\[ B = Y \]

This finally reduces us down to a two-switch circuit in place of the four original switches.

George J. Beaupre
Danvers, Mass.
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Circle 11 on reader service card

AUGUST 1973 • RADIO-ELECTRONICS 17
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RE-21

Circle 8 on reader service card

AUGUST 1973 • RADIO-ELECTRONICS 21
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FLOOR POLISHERS AND CARPET SCRUBBERS

by JACK DARR
SERVICE EDITOR

A LOT OF HOMES NOW HAVE A COMBINATION OF FLOOR-COVERINGS: partly hardwood and partly carpeting. Cleaning carpets was once done by large gentlemen pushing monstrous machines back and forth over them. There were rental machines, but even these were pretty hefty, up around 75 pounds. Now, we have "home versions", which will not only scrub carpets, but polish and wax wood floors. With the new, tough, light-weight plastics, they're light enough to handle with ease.

These are pretty simple machines. They look like the "stick" type vacuum cleaner. A plastic tank on the handle holds the cleaning fluid; a valve on the handle lets the operator use any amount needed. A small motor drives a large round brush, or a pair of brushes. These are built into a compartment so that the cleaning fluid can be dribbled down over them and to the floor without spraying the vicinity.

In operation, the machine actually "rides" on the brushes; a pair of small wheels are generally mounted on the back of the case for easy transport. Either carpet-cleaning compound or a special thin floor wax can be used in the tank. Heavy waxes will clog the valves and make a cleanup necessary.

For applying wax, and polishing wooden floors, large felt pads are attached to the bottom of the brushes. Most people use two sets, one for applying wax and a dry set, for the polishing.

You'll find some unusual things in the motors and brush-drives. In the single-brush machine, a large eccentric counterweight is used, to balance the brush and keep the machine from vibrating too much. In this model, the brush itself has an eccentric drive, such that the brush revolves, and actually moves back and forth at the same time. This leaves a track of small circles on the floor.

In the two-brush machines, the brushes are usually built so that they rotate in opposite directions. This keeps the machine from wanting to "skate" to one side when it's running.

This also leads to some novel designs and features. In one popular model, the motor has a shaft coming out of each end, with a worm gear on it. These go into small gear boxes, where they drive pinions which turn the brushes. Looking at one end of the motor, the shaft is turning clockwise. Looking at the other end, this is turning counterclockwise. Other models use straight gear-boxes, and take advantage of the fact that in a multiple gear train, every other gear turns in the same direction, and the ones between opposite.

In the first machine, the brushes are screwed onto the ends of the shaft. A shaft turning counterclockwise must have right hand threads, and one turning clockwise must have left hand threads. Otherwise, the brushes will unscrew themselves while the machine is running. If you take the brushes off one of these, be sure that you have the one with the correct threads, or it won't start on the shaft. If it won't go, try it on the other shaft. Other types have brushes which bolt to flanges on the ends of the driving shafts, or slip over splines and are held in place by spring clips, etc. If you can't see any bolts or clips on the hubs of the brushes, they are very likely to be the screw-on type.

"Hydraulically", these are pretty simple. The cleaning fluid is poured into the tank, which can be taken off the handle by opening the latches. The bottom of the tank fits into a receptacle, and the fluid comes out through a small pipe, also fitting into a hole in the bottom of the receptacle. There is a control valve, actuated by a long rod going to the top of the handle. Sometimes, this is on the handle, or in the bottom of the tank itself. It's usually a simple flapper valve.

The only problems you'll find in this part is leakage in the valve, which is mostly due to something getting into the tank and lodging on the valve seat. This can be cleaned out by draining the tank and turning it up-

(Continued on page 97)
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The SA-8000X has an exclusive combination of controls and circuitry that adjusts to the coefficients of any matrix method. The Acoustic Field Dimension (AFD) controls and the Phase Shift Selector provide a variety of blendings that encompass every popular matrix system. Even some that haven't been tried yet. And the same controls can compensate for poor room acoustics. Or undesirable but unavoidable speaker placement.

The Technics "Total 4-Channel" concept shows just as clearly in the rest of the front panel. A well-thought-out set of controls manage both volume and balance. There's a large master gain surrounded by separate controls for each channel. And any balance set with the individual knobs is maintained when the master is adjusted.

The rear panel reflects the same versatility. With plug-ins for three 4-channel tape decks. Plus provisions for future discrete FM.

Technics’ attention to detail continues inside the SA-8000X. With sophistications like a pair of 4-pole MOS FETS and a 3-gang linear tuning capacitor. A trio of 2-element ceramic IF filters, a new type of epoxy resin coils as well as monolithic IC's in the multiplex circuit.

The four directly coupled amplifiers are very gutty in the bottom end and can be "strapped" together. So that in stereo, four amplifiers work as two, which more than doubles per-channel wattage in that mode.

The combined effectiveness of the whole design produces specifications like these:

<table>
<thead>
<tr>
<th>FM TUNER SECTION</th>
<th>AMPLIFIER SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>1.9µV</td>
</tr>
<tr>
<td>Selectivity</td>
<td>65 dB</td>
</tr>
<tr>
<td>S/N Ratio</td>
<td>65 dB</td>
</tr>
<tr>
<td>Capture Ratio</td>
<td>1.8dB</td>
</tr>
<tr>
<td>1 kHz RMS Power</td>
<td>64w</td>
</tr>
<tr>
<td>4-channel operation</td>
<td>64w</td>
</tr>
<tr>
<td>2-channel operation</td>
<td>84w</td>
</tr>
<tr>
<td>IHF Music Power</td>
<td>160w</td>
</tr>
<tr>
<td>4-channel operation</td>
<td>160w</td>
</tr>
<tr>
<td>Power Bandwidth</td>
<td>50Hz-40kHz,-3dB</td>
</tr>
</tbody>
</table>

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Healthkit GR-110 VHF Scanning Monitor

Automatically scanning the 146 to 174 MHz vhf Emergency Radio Service Band the GR-110 is 1000% more convenient than manually tuning a conventional dial receiver. Anyone who wants to monitor more than a single frequency on this busy band will find the manual radio annoyingly frustrating in comparison to the auto-scan technique. The Healthkit GR-110 gives hands-off operation freeing the user for other tasks.

The receiver demodulates narrow-band FM broadcasts with less than ±7.5 KHz deviation. User specified in frequency, the desired channels are tuned with separately ordered crystals. The kit builder can purchase crystal certificates from Heath which are then mailed to the crystal manufacturer before starting to put together the kit. A 9-MHz limit is imposed between the highest and lowest frequency crystal.

The 50-ohm antenna terminals feed a two-stage FET rf amplifier well known for low intermodulation distortion as a result of their square law transfer characteristics. Sensitivity is better than 1-μV for 20 dB of quieting. A third FET is used for mixing. The oscillator input to the mixer is derived from eight crystal controlled oscillators. The output of one oscillator is selected and fed through a tripler. The crystals are sequentially selected at a 17 per second rate by diodes controlled by IC logic centered around a TTL 7490 decade counter. A BCD-to-decimal decoder supplies the diode select currents. Only eight of the ten decoder outputs are used with one of the binary inputs grounded so the two extra counts 9 and 10 simply rescans channels 0 and 1.

A second seven segment decoder converts the BCD output of the 7490 to the seven segment display needed to drive the front panel incandescent display tube. The display logic can be wired to be lit all the time including scanning time or to be lit only when receiving a channel. We preferred the latter since it eliminates any extraneous display and unnecessary flicker.

Eight push button switches allow bypassing any of the channels.

Manual selection of channels is opted by putting the auto/manual switch in the manual position and stepping the frequencies with the select switch.

The mixer output feeds an LC/crystal filter to give an i.f. rejection greater than 80 dB. Two FM quadrature detector IC's are used, one strictly as an i.f. amplifier and the second as an i.f. amplifier-FM detector. The detector stage of the first amplifier is wired to give additional gain. The FM detector outputs drive the squelch and audio output circuitry.

Three boards are wired, a large scan circuit board, the i.f. and the audio boards. Construction proceeds with the usual Heathkit straightforwardness although there were a couple of minor snags probably attributable to our early production model. Initial turn-on was delayed by a half hour because of a poor solder joint, verifying Heath's contention that most kit problems are caused by poor soldering. Total construction and alignment time comes to about 12 hours.

While the Heath receiver is no worse than the other scanning and non-scanning receivers we have seen, recent improvements in i.f. amplifier-detector IC's should allow improved squelch design. This is particularly important where there is a great deal of switching on and off of signals.

There are a lot of goodies combined in this kit which among things includes 30 transistors, 8 IC's and 17 diodes well worth the $119.95 price tag. Crystal certificates are an additional $4.95 each.
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RADIO-ELECTRONICS • AUGUST 1973
CALCULATORS

how to keep them running

The electronic calculator is perhaps the newest of all consumer devices and one that requires special troubleshooting and servicing techniques.

by PATRICK N. GODDING*

SMALL ELECTRONIC CALCULATORS REQUIRE more sophisticated troubleshooting techniques than those used to service many other kinds of electronic equipment. In addition to the basic procedures used in discrete transistor circuits, calculator servicing requires some understanding of integrated circuits and logic.

To service a defective calculator you will need a pencil-type soldering iron (30 to 40 watts at about 700°F), small screwdrivers, solder remover, sharp knife, diagonal cutters, and needle-nose pliers. A vorn and oscilloscope are the only mandatory pieces of test equipment, but a frequency counter can come in handy at times. Some problems can be solved with no test equipment at all or possibly a vorn alone.

Basic troubleshooting

A few general procedures will save lots of time and reduce the prospects of inadvertently damaging additional components in an already defective machine. First, give the machine a careful visual inspection. Burned or bubbly resistors, blown electrolytic capacitors, solder bridges, and other obvious malfunctions can usually be quickly found and corrected. If the problem involves a destroyed component, never install a replacement part until the cause of the problem is found and corrected. Never use a replacement component of poorer quality than the original one.

Next, while it may be necessary to turn on a calculator to find the symptoms of a problem never leave a malfunctioning machine on longer than necessary. A good example is the overflow indicator. If the readout devices don't light, multiply two numbers whose answer will give an overflow indication. If the "Error" signal is displayed, the problem is not in the input, control, or arithmetic sections of the machine. In this manner possible causes of the trouble can be quickly identified.

Finally, if a thorough visual inspection fails to reveal the problem begin troubleshooting at the point of the improper indication and work backwards checking each associated component. If more than one problem exists, begin with the simplest since it frequently leads to the major trouble spot. Here's a typical example:

In Fig. 1, the "C" segment in the display fails to light. Follow these steps to isolate the trouble:

1. Check continuity from the "C" segment to Q5's emitter
2. Check Q5's base for proper incoming signal
3. Check Q5
4. Check R15
5. Check R14

To cover as many troubleshooting procedures as possible, the remainder of this article is divided into subsections describing the problems and symptoms common to the various subsections of almost all electronic calculators. The accompanying Troubleshooting Chart summarizes this material and helps pinpoint many trouble sources.

Keyboard

The keyboard consists of an array of switches either connected directly to the input LSI chip or connected as a matrix which is scanned by the input chip. The latter technique is usually used in multi-chip calculators.

In the direct input technique such as the one shown in Fig. 2, the 0-9 digit keys are connected to a diode matrix which provides a BCD (Binary Coded Decimal) output. An open or shorted diode will cause incorrect segments on the display readouts to light. A shorted keyboard switch, either digit or function, can cause a great variety of symptoms.

After eliminating other possible causes of the problem, disconnect the keyboard and make entries manually. If this cures the problem, check each switch in the keyboard for continuity. If only one key fails to work properly the problem is in the switch itself; an open line to the input section, or the input LSI chip. Another possible cause of trouble is input lines from the keyboard shorted to one another. This problem can be identified by using a vorn to check for shorts.

In most multi-chip calculators, the input chip scans a keyboard matrix to detect entries. In Fig. 3, the keyboard matrix for a MITS 816 desk calculator, the "X" lines are pulsed by the input chip and the "Y" lines are at a negative voltage. When a key is depressed there will be pulses on both lines common to the closed switch.

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The pulses can be seen on an oscilloscope, and, if not present, the problem is either in the keyboard or the input chip. If pulses are seen on a "Y" line with no keyboard entry, that particular line is shorted to one of the "X" lines at the keyboard, the input chip, or one of the interconnection lines. When no pulses appear on the "Y" line with a correct entry, the entry switch is open. An "X" line with no pulses means the input chip is not functioning or the line is shorted (probably to ground). A non-functioning chip is caused by an internal defect, lack of clock pulses, or insufficient voltage. If any key clears the machine, it is shorted to the CLEAR key. And when the CLEAR ENTRY key is shorted the normal display will be on, but the machine will not accept entries.

Power supply

Usually consisting of a transformer and one or more bridge rectifiers, some of which are regulated by either a transistor or Zener diode, the power supply is the major source of trouble in most electronic equipment. A close visual inspection is important when a malfunction points to the power supply. A shorted supply line, for example, is indicated by a burned or bubbly series resistor and is usually caused by a shorted regulator, shorted filter capacitor, or possibly a short in the LSI circuitry.

LSI chips generally require two regulated voltages, \( V_{\text{DD}} \) and \( V_{\text{IH}} \). \( V_{\text{DD}} \) is a higher voltage and if open or shorted no entries are possible and an error indication is sometimes seen. With a missing \( V_{\text{IH}} \), there is no display and no entries can be made.

If the regulated driver voltage is shorted or open, the condition of the driver circuitry determines whether the display readouts are all on or off. But one of these malfunctions will be present.

Both gas discharge and electro-fluorescent readout devices require a large anode voltage with the latter also requiring a filament voltage. The entire display is off when either of these voltages is open or shorted.

Fig. 4 shows a typical power supply for a calculator using electro-fluorescent readout devices. The +45V is anode voltage and the -2.4V is for the filaments. The -26V and -14V are \( V_{\text{DD}} \) and \( V_{\text{IH}} \) respectively, and the -5V is the segment and digit drive bias voltage. If a bridge rectifier diode shorts, the output voltage is reduced. If an input filter capacitor opens, the readout tubes receive unfiltered voltage and appear to flicker on and off. If a capacitor shorts, its voltage line is at zero potential and one or more bridge rectifier diodes may short.

Three of the lines shown in Fig. 4 use Zener diodes for regulation. If the output is open, the total current in the line goes through the Zener diode, sometimes causing it to short and the series resistor to bubble. The voltage line reads higher than normal if the Zener opens. This may or may not cause a problem, and if the difference

![Image](image-url)
between the peak voltage and the Zener's rated voltage is only a few volts, the machine should operate normally.

Clock

LSI calculators, just like full-scale digital computers, require a time base to synchronize all operations. The timing pulse generator is called the clock, and it usually consists of an astable or free-running multivibrator or series of gates in a TTL chip. The former approach is used mainly in LSI calculators that require a two-phase clock. These are usually one- or two-chip machines. If the timing pulses are missing at the output of the clock IC, the problem is either in the chip or its associated components, or the chip's supply voltage is open or shorted.

A representative TTL clock is shown in Fig. 5. The clock pulses are fed through a buffer for interfacing with the LSI chips, and the absence of pulses can frequently be traced to the buffer transistor. Check for proper voltage at both the transistor and the chip. If voltages are correct, check the clock chip in an IC tester or try it in another calculator. CAUTION: To avoid possible damage to the IC, never substitute a good chip for a bad one until the problem is discovered and eliminated.

Display drivers

The driver system for a display consists of switching transistors which are sometimes arranged in a Darlington configuration for added current gain. At any one time, a driver transistor is either on or off. Driver circuits are required for the various digits and the segments within a digit, and both are described below.

Digit drivers

The digit drivers are fed from the output LSI chip, and their output goes to the anode of the display device. Fig. 6 shows a typical Darlington configuration used in most drivers. Initially the base of Q15 is positive with respect to its emitter and is driven into saturation. This turns Q16's base negative, turning off Q16 and the digit. When the proper command is received, the digit line output goes negative. This turns Q15 on, which forces Q16 into saturation, and the digit turns on.

A digit which is constantly on can be caused by a faulty output LSI chip, open interconnect leads from the chip to the driver, Q15 open, Q16 shorted, or the readout anode shorted to +V.
Conversely, a digit that never turns on is caused by the opposite of any of the above problems.

**Segments drivers**

The same basic circuit shown in Fig. 6 is used to drive the segments of the readout devices, but a separate driver is required for each segment. The information coming from the output chip is fed through a BCD to seven-segment converter and then is sent to the segment drivers.

In some driver circuits, such as the one shown in Fig. 7, a shorted transistor can cause the gate in the converter feeding it to short. This is a good example of why a good IC should never be randomly substituted for a defective one. If at all possible, test it in another calculator or in an IC tester. If it’s bad, find the cause of the problem before trying a new chip.

Operation of the driver in Fig. 7 is as follows: With no segments illuminated, the output BCD lines are at -5V and the converter outputs are at OV. If a 2, for example, is entered on the keyboard, it will appear on the four BCD lines as: B1 = -5V; B2 = OV; B3 = -5V; and B4 = -5V. This code at the input of the BCD converter forces the A,B,D,E, and G outputs to go to -5V and the remaining segments stay at OV. The -5V signal at Q1’s base cuts off Q1, turns Q2 on, and causes the appropriate segment to be illuminated. This circuit is virtually identical to the digit driver discussed earlier, and the same service procedures apply.

**Display devices**

Most electronic calculators employ light emitting diode, gas discharge, or electro-fluorescent display devices. The LED readout has characteristics similar to those of a conventional diode. A typical seven segment LED readout has eleven connection pins—one per segment, one for the decimal point, and three for the anodes. LED readouts usually employ a series string of at least two diodes per segment to give dots which merge into a line pattern.

If all the diodes in a particular segment are not illuminated, the readout is defective and should be replaced. When two segments in an LED readout are shorted together internally, isolating the bad readout from others in the display may prove difficult. One way to find the bad readout is to measure the resistance between the two segments on each readout with a high-sensitivity ohmmeter such as a bridge comparator. A second method is to remove each LED readout from the display and test it individually until the defective (continued on page 80)
GLASS PLATE

WAVE GUIDE

MAGNETRON

STIRRER

Microwave ovens are comparatively simple and easy to service. Be prepared when you’re called to fix one.

by D. R. MACKENROTH

MICROWAVE OVENS ARE NOW USED IN trains, on airplanes and ships, in restaurants, and are proliferating in private homes as well. If a microwave oven fails to operate correctly, most consumers rely on appliance service- men to repair them, when in fact, the devices contain electronic circuitry that should more properly be maintained by qualified electronic technicians. TV and other consumer electronics service technicians should become familiar with the principles involved in microwave ovens, as well as the specialized service techniques which they require.

How it works

About twenty-five years ago, so the story goes, Dr. Percy Spencer of Raytheon walked past a radar device with a chocolate bar in his pocket. The chocolate became very warm and melted. Intrigued, Dr. Spencer and his associates found that they were able to pop popcorn and heat other foods with the microwave radiation from the radar.

This is the principle used in the modern microwave oven. The oven itself is nothing more than a tightly sealed metal box as shown in Fig. 1. Microwaves are generated in a special type of tube, called a magnetron, and fed into the box through a waveguide. A stirrer is also placed in the box. This is simply a slow-speed fan with metal blades. As these blades rotate, they reflect the microwave energy, bouncing it around to all corners and areas of the interior of the metal box.

Without the stirrer, standing waves would be created in the oven, and some regions would be "hot" and some would be "cold".

The heart of the oven is the magnetron tube (see Fig. 2). The tube is basically a diode with a cylindrical cathode surrounded by a cylindrical anode. A strong magnetic field is created by a large permanent magnet or electromagnet. This field affects the flow of electrons from anode to cathode.

A high negative dc voltage is applied to the cathode from a power supply. The magnetic field changes the trajectories of the electrons flowing from cathode to anode, causing them to return toward the cathode. The tube oscillates at a high frequency (2450 MHz is the FCC-regulated operating frequency for microwave ovens), and the cavities of the magnetron act as resonant circuits. Energy is given up to the cavities by the electrons, producing rf power which is coupled into the waveguide by a small "antenna" at one end of the tube.

As can be seen in the typical schematic of Fig. 3, most ovens also have a timer that turns the oven off when cooking is completed, a fan that (continued on page 42)
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(James Gupton’s address available upon request.)

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A microwave oven never should be operated completely empty. If it is, you can get arcing within the oven and a damaged magnetron may be the result. Always place a load in the oven when it is on. A good load, as well as a test of the oven, is to place a cup of water into the oven. Then set the timer for five minutes. If the oven is operating correctly, the water should be boiling in 1.5 to 3 minutes. Don't use metal utensils, pots, or foil in the oven—this can also cause arcing, since metal surfaces reflect the microwaves and do not absorb them.

For a more accurate measure of the output power (in watts) of the oven, measure the temperature rise of a specific amount of water in one minute in the oven. Measure 500 milliliters of tap water into a ceramic or china dish, heat the water in the oven and measure the temperature rise. Use the formula:

\[ P = (T_2 - T_1 \times 35) \]

where

- \( P \) = power in watts
- \( T_2 \) = temperature in °C after heating
- \( T_1 \) = temperature in °C before heating

Don't leave the thermometer in the oven when it's on, since the mercury is a metal and will reflect microwaves, perhaps damaging the oven.

If the oven doesn't go on at all, check the interlock and timer switch loop. Clean the oven door and make sure that it will close completely, since small particles of food can work themselves into the seals and keep the door from activating the interlock switch. If food does not heat evenly in the oven, check the operation of the stirrer.

**Magnetron and high-voltage tests**

If the oven appears to operate normally (the stirrer turns, the timer works, etc.), but there is poor or no heating, the trouble is probably in the magnetron or its power supply. If you are checking these circuits, make sure the unit is unplugged and you've bled the filter capacitors first.

Check the magnetron for loose or dirty connections. It may be a good idea to clean the contacts of the magnetron and the waveguide with metal polish, then remove any residue with alcohol. Dirt or corrosion can severely cut down the efficiency of microwave circuitry. Be careful working around the magnetron, though, since most magnetron tubes have a warranty and
they are expensive—typically well over $100 each.

To check the magnetron and associated circuitry, the first step is a simple resistance check. The heater of the magnetron should read about one or two ohms, and the resistance from the cathode to the anode of the magnetron should be infinite.

A good check to make is to read the anode current of the magnetron. Some manufacturers have placed a 10 ohm, 5 or 10-watt resistor in series with the rectifier diode, and reading across this resistor with a dc voltmeter gives a reading for the anode current. If, for example, the voltage drop across the 10-ohm resistor is 3.0 volts, the anode current is 300 mA. If the manufacturer, as in the diagram in Fig. 3, has not inserted this resistor, you can put one in the circuit for test purposes. Place the resistor, a healthy 10-ohm, 10-watt wirewound type, between ground and the cathode of rectifier diode D3. Remove the resistor when tests are completed.

Although manufacturer’s specifications should be checked to make sure, anode current in most magnetrons used in microwave ovens will usually range from 250 to 320 mA. A small fluctuation, 5 to 10 mA on either side of the reading is normal, but wide changes of anode current indicate that the magnetron tube has an internal short or is moding (oscillating at a frequency other than the designed frequency of operation). Although anode current is normally not adjustable, the circuit in Fig. 4, from the Westinghouse microwave oven, includes a coil for the electromagnet of the magnetron and a 5000-ohm 25-watt, adjustable wirewound resistor. This resistor is used to set the magnetron current to its optimum value (300 mA in the case of this Westinghouse oven).

If anode current is nonexistent or very low, all components in the power supply should be eliminated before the magnetron is changed. With a high-voltage probe, measure the anode voltage, but remember that it will normally be in the 2500-4000 Vdc range. If you have to change the magnetron, be very careful to get all seals and gaskets back in the way they came out. Lay them out on the bench in the order they are removed to facilitate reassembly. Fig. 5 shows a typical magnetron installation, as well as a partial interior of a microwave oven.

A visual inspection of the magnetron may reveal faults. A crack in the glass envelope around the antenna, for example, may indicate excessive vibration or rough handling, or possibly that the magnetron was installed incorrectly. The interior of the tube will take on a milky, whitish color if air has gotten into the tube. If a sunken place or a bubble has developed on the glass envelope, it means that the magnetron probably has been overheated by operating it without a load in the oven.

When a new magnetron is installed, the old one should be kept, and the serial numbers of both tubes recorded. For the warranty to be valid, the old magnetron must be sent back to the factory, along with the serial number of the tube that was newly installed.

Leakage, seals and testing

The Bureau of Radiological Health of the Department of Health, Education, and Welfare, regulates the permissible radiation that can emanate from a microwave oven. Under these Federal standards, radiation leakage...
I needed a robot phone gadget, and I unpacked my spanking-new one with a little anxiety. After all, how good could such a machine be when it retails for $129.95? Next, I opened the manual and read. This was no ordinary tape recorder that you could turn on and use right away without instructions; it's two very specialized tape recorders in one package and it's designed to do just one thing in this world: answer the telephone.

I got to the section on recording your answering message. There's a continuous-loop of tape for this message and it holds 30 seconds worth of your own voice. Thirty seconds! How would I ever record that much material; after all, what do you say besides "Hello," and "Please leave your name and phone number"? I soon found out. I read the suggested sample message in the instruction book, then composed a revised version of my own:

"Hello. This is Eugene Walters. I'm out right now, but will return shortly. That's right. You're talking to a friendly robot, and it'll take a message as well as the best secretary. So when the beep sounds, won't you please leave your name, phone number and any brief message that you like. I'll return your call as soon as I can. Remember, wait for the tone before you start talking, then leave your name and phone number. Yes, I will call you back. Thanks for calling, and wait for the tone before speaking."

I read it over, got out the stop-watch and put on my best radio-an-ouncer's voice. On three readings, I got 32 seconds, 27 and finally 29.

My new phone robot uses two tape drives. One is a continuous-loop drive for the answering message and has a 30-second duration. The other is a reel-to-reel tape that's locked to the reels at both ends. According to the book, it's long enough to hold 30 half-minute messages.

A machine like this—and other inexpensive phone recorders, work basically the same way. The outgoing (answering message) is recorded on an endless loop of tape. At the end of the message, there is either a strip of metal foil, or a physical change in the tape to operate a switch. In the Phone-Mate, a piece of leader tape is spliced into the loop, and this leader is cut down to about half its usual width (see Fig. 1-a). A wire feeler drops down in this reduced-width area, operating a sensitive snap-action switch which in turn operates two relays: (1) stop the outgoing message tape (2) release the stored capacitor charge which delivers a short oscillator tone burst and (3) start the message recorder.

The block diagram in Fig. 2 shows a ring charge circuit. On incoming calls, a neon bulb is lighted by the ring signal and a 47-µf capacitor charges from the ring current. By the middle of the second ring the capacitor is charged enough to trigger RY1, the first of two control relays. This starts the outgoing message cycle.

At the end of the outgoing message tape, the switch feeler drops down, switching off RY1 and the out-

---

**Fig. 1—REduced TApe WIDTH** (a) and a slot in tape (b) are two ways of controlling the recorders.

**Fig. 2—BLOCK DIAGRAM** of a typical telephone answering machine connected to the incoming telephone line. Some message recorders use cassettes for quick removal and storage.
going recorder and closing RY2, which latches. RY2 triggers a short oscil-
lator tone burst (the "beep"), pow-
ered by a stored capacitor charge, and
starts the message recorder—a rim-
drive unit that runs at approximately
3½ ips. At the same time, an L-C cir-
cuit with a time constant of about 30
seconds starts to charge. When this
circuit is fully charged, it dumps its
load across RY2, causing it to unlatch,
shutting down the entire machine. The
machine is now ready for the next
call.

Acting as an interface between
the phone line and the recorder is a
phone-line matching circuit, which
looks to the phone line like any ordi-
nary extension telephone. It’s usually
at a telephone location, and a “sand-
wich” phone plug is supplied which
plugs into a standard telephone com-
pany jack, and accepts the jack
phone’s plug on its face (see Fig. 3). If
you’re using the unit with a phone
that isn’t equipped with a jack con-
nexion, you can hook it up as shown
in Fig. 4. The other end of the cable
plugs into the Phone-Mate via a six-
pin DIN connector.

Tapes can be changed when worn
or damaged. Or for that matter, the
outgoing message tape can be short-
ened easily, simply by snipping out
some tape where the leader is spliced
in, removing a turn or two of tape,
and resplicing. Thirty seconds does
seem overly long for an outgoing
message.

To avoid these problems, a more
sophisticated (and more expensive)
recorder is called for. Several models
made by Record-a-Call offer definite
advantages. Depending on the model
purchased, messages are taken on
open reel tape (3½ ips, capstan driven)
or on a standard cassette—and in ei-
ther case, the tape can be quickly re-
moved for storage. The outgoing mes-
sage is on a built-in endless loop tape,
and standard length for this message
is 20 seconds—although the tape can
be changed easily for longer or shorter
messages.

The outgoing message tape is set
up for three-channel operation; a selector knob picks one of the three tracks, marked for alternate messages. Thus, the user can change outgoing answering messages by turning the selector knob. This change in message capability is especially important for professional offices, where a doctor may be on call and wishes to direct the caller to dial another number, or may be on an emergency, or may simply want the caller to leave a message.

Businesses may want to use different messages for lunchtime closings, evenings and weekends. It's simpler than changing the message cassette as some recorders do, although it's limited to choice of three such messages. Still, this is adequate for most businesses. The message channel is changed by moving the head assembly up or down with the selector knob.

Like other answering equipment, these machines plug into a phone jack with a sandwich plug. For installations where the jack isn't available, and where any kind of direct connection might raise Cain with the local telephone company, equipment is available that makes no electrical connection at all. Instead, the telephone handset is placed on an acoustic coupler and a solenoid-operated finger operates the telephone's relay plunger. This may look a little Rube Goldbergian, but phone company rules are still open to such a wide variety of legal interpretations, that this type of arrangement is all that can be used by some businesses.

In some machines, the outgoing message tape uses a central cutout for triggering, as shown in Fig. 1-b. The cutout portion in the center of the tape admits a feeler which operates a switch to trigger the message-taking cycle. The electronics in these units is highly sophisticated. Such features as adjustable ring lets the user leave the recorder connected and turned on at all times. By setting the unit to answer on the fourth or fifth ring, the machine will even answer the phone when the user is on the premises but too busy to answer. In cases like this, the outgoing message option chosen may simply say, "I'm tied up at the moment but will pick up the phone in a minute or so. If you can't wait, please leave a message after the tone."

Unlike less expensive machines, the better units are caller-controlled; they'll take as long or short a message as the caller wants to leave, and will continue to record until he hangs up. Some manufacturers provide the option of voice-activated control, and such machines will stop recording if there are "six or eight seconds of silence. Because of the unlimited time of recording on these units, it's possible to call your own office and dictate lengthy memoranda or even letters for your secretary, who can pull the cassette and replace it instantly with a fresh one while she's transcribing dictation.

Another type of phone-answering unit is the announcer. This species is favored by movie theaters and special services like "dial-a-prayer" and others. A recorded outgoing message is played for the caller, and it can be a fairly lengthy one, depending on the length of the cassette used. The message can be changed instantly by simply replacing the endless-loop cassette. The tape itself is a specialized continuous-loop cassette/cartridge of a non-standard size. It's somewhat larger than a standard cassette, and much smaller than an 8-track cartridge. This same cassette is used by other manufacturers too.

The low-cost phone-answering machine has its place in the scheme of things. These machines, because of their low cost, are appealing to the consumer, hobbyist and private citizen who would like to have his phone answered on a 24-hour-a-day basis.

Most sales agencies also offer service and usually have service contracts that are often figured into the selling price. The solid-state electronics usually don't create problems; the main service areas involve replacing tapes and possibly adjusting and cleaning relays. The serviceable mechanical areas are all accessible and pretty much self-explanatory in their operation.

Special options add to the robot's versatility. The remote message pickup can operate in several ways, depending on the unit. On one machine, it's
SLOT IN OUTGOING-MESSAGE TAPE activates switch to stop the announcement loop and turn on the message recorder in the Record-A-Call answering machine.

A NOTCH IN THE MESSAGE TAPE controls change-over in the Phone Mate. The feeler of a sensitive snap-action switch drops into notch to activate process.

PHONE-MATE answering machine can be used with any telephone.

Radar Oven Repairs (continued from page 37)

from a microwave oven cannot exceed 1 mW per square centimeter prior to factory release and 5 mW per centimeter measured at a distance of 2 inches from the oven at any time thereafter.

Oven doors are usually sealed primarily by a choke section, a quarter-wavelength slot around the inside of the door. As you can see in Fig. 6, this is backed up by a secondary, Teflon-covered metal-to-metal seal. Particles of food or grease, or wear on the seals themselves, can cause leakage, and an unconnected neon bulb held next to the edges of the door, will indicate leakage. If the edge of the door feels warm to a finger run around it while the oven is operating, leakage is probably excessive.

More accurate tests of leakage are performed with commercially-made leakage testers, such as International Crystal Corporation's Microlite 287 and Microdek 310. The 287 is a simple bulb that glows when radiation levels exceed 5 mW/cm². The Microdek 310 has a meter that reads 0.4 mW to 23 mW in two scales.

To test an oven for leakage, place a measuring cup or bowl filled with water in the oven. Close the door, turn on the oven, and set the timer for the longest available time. The meter probe usually has a spacer that places the antenna of the leakage detector at the proper distance from the oven. Place the tip of the probe into one of the cracks where the door contacts the oven and slide it back and forth along the door. At the point where maximum indication is obtained on the meter, the level should be recorded and the meter turned 90° and another reading taken. The sum of the

FIG. 6—RADIATION FROM INSIDE OVEN is prevented by a quarter-wavelength slot or trap section around the door perimeter.

(continued on page 90)
THERE ARE AT LEAST THREE REASONABLE ways to make your Superclock (Radio-Electronics, July and August 1972) or any other parallel-load clock self-resetting and always accurate. One is to use National Bureau of Standards stations WWV and WWVH. A second is the television timing system, which is still experimental. A final way is with WWVB, a 60-kHz station of the National Bureau of Standards broadcasting from Fort Collins, Colorado. WWVB broadcasts a continuous time code 24 hours a day. The code is in Greenwich Mean time, but this is easily converted to local time with the Time Zone conversion chip in the Superclock. The performance of WWVB varies across the country, being best in the mountain states and poorest far east, far south, and in noisy industrial or high thunderstorm areas. Depending on your area, you might get reliable reception with a very simple system, or you might not get good enough results to reliably run a clock even with the most exotic techniques. We'll try to show you how to build up several receivers, ranging from the simple to the complex, along with a suitable decoder. What we won't do is guarantee results—but with our circuits and subsystems as a start, maybe you can avoid all the pitfalls and mistakes we made along the way.

Even if you can't get continuous coverage, a late night update can usually be used to keep your clock accurate, with the crystal timebase filling in between updates.

The systems we'll talk about were tested in Phoenix, Arizona, where the simplest system worked very well and in San Antonio, Texas, where the more complicated system gave acceptable performance in the middle of a high industrial noise and high topological storm area. Your reception job will be extremely difficult east of the Mississippi, but NBS coverage of the entire US by WWVB is termed "adequate" and maybe you'd just like to try this exciting project.

About WWVB

You can find out about all of the NBS services by getting a copy of NBS Frequency and Time Broadcast Services, NBS Special Publication #236 for $25 from The Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 0303-0666. Or, you can subscribe to the NBS Time and Frequency Services Bulletin, a monthly publication that gives day-to-day operating details of the various stations, announces upcoming changes, and so on.

WWVB transmits a continuous 60-kHz carrier 24 hours a day, except for occasional Tuesday maintenance schedules. The transmitter is located in Fort Collins, Colorado and the transmitted power is 15,000 watts. Field strength contours for the United States are shown in Fig. 1. Except for transmission code modulation we'll tell you about in a minute, the signal is all carrier—there are no voice announcements, no tics, geoalts, or anything else. At the beginning of each second, the carrier suddenly drops 10 decibels in amplitude, giving the impression of "half value" on a peak-to-peak scope display. The signal stays low for a portion of the second and then it goes high again, dropping on the next second.

One bit of an elaborate time code is presented each second by the duration of the low part of the code. If the signal stays low for 0.2 second, you have a "0." If it stays low for 0.5 second, you have a "1." If it stays low for 0.8 second, you have a "P" or framing pulse. These pulses are shown in Fig. 2. The code repeats every minute. It starts out with two "P" pulses in a row identifying the start of a minute. Next comes the "10 minutes" information, followed by the "seconds" and another "P" pulse at ten sec-

**Details on various 60-kHz reception techniques that can make your superclock self-resetting and always accurate. These are strictly experimental systems, described for advanced electronics buffs only**

by DON LANCASTER
seconds. This is followed by the “ten hours” information, and the “hours” information, ending up with a P pulse at 20 seconds. Beyond 20 seconds, the code goes on to give you the day in the form of a number from 1 to 365 or 1 to 366, and some “fine grain” time information we won’t be using.

The code repeats once each minute, updating the information for that minute. Since it takes at least 10 seconds to get out the minutes information, the code runs 10 seconds late. To beat this, you preload a “10” into your seconds counter at the time you update the minutes information. The time-zone chip in the Superclock automati-

**FIG. 1—SIGNAL STRENGTH of WWVB broadcast over the continental U.S.**

and in industrial areas. So we have to start with a stable, narrow-band receiver. If we are lucky, that’s all we’ll need. If not, we’ll have to go to some more exotic reception techniques.

**Building a preamp**

Regardless of what you do with your receiver, a good preamp is absolutely essential. The one we’ll tell you about is simple and cheap—but has been the result of many hours of painful testing and lessons learned the hard way.

Before you do anything, if you could beg, borrow, or steal five minutes of time on a real, high-quality, military field strength receiver (Singer, Empire Devices, etc.) with a low-frequency plug-in, you can get a fair idea of how hard the signal will be to receive. Use a vertical antenna, a location above all local metal, and try it an hour after dusk. Tune to 60 kHz and watch the 5 meter. If there’s any hope at all, you should get a fairly strong signal on the meter with a distinctive once-each-second sudden drop in amplitude. You should be able to read the code except for occasional noise pulses, and the background level should drop below the minimum signal as you tune off frequency.

A shielded loop antenna is essential for the preamp. It’s shown in Fig. 3 along with the complete preamp schematic of Fig. 4. Start with 6 feet of copper tubing, insert a piece of 12-conductor surplus shielded cable, and bend it into a loop. Terminate it in a conduit housing that’s big enough to hold the preamp. Be sure to use a plastic fitting on one end to keep from getting a shorted turn on your shield. These are available in many hardware and electrical supply stores and are intended for shockproofing electric hot water heaters. The shield must be double (the cable plus the tubing) and has to be this thick because of the skin effect at 60 kHz requiring considerable shield thickness. The final form of the loop will be slightly over 2 feet in diameter.

The loop is completed by wiring the conductors together to form a 12-turn loop and then soldering the shield and tubing at one end only. Tune this coil to 60 kHz with high-quality polystyrene capacitors or the much more expensive silver micas. Any other capacitor type is unsuitable. The coil Q should be around 25 to 40. More will cause temperature and tuning problems, less will let in too much noise.

**TRADITIONAL LOOP ANTENNA. Note insulating section on shield.**

**WWVB PREAMP IS IN THE LOOP ANTENNA. It should be completely shielded.**

**FIG. 3—SHIELDED-LOOP ANTENNA for receiving WWVB broadcasts.**

**FIG. 4—PREAMP SCHEMATIC. Three-transistor circuit is easy to build and inexpensive. Total cost is about $8.**
FIG. 5—A SIMPLE WWVH RECEIVER can be built around a National LM372 IC. Just follow this basic schematic.

If you’re real lucky, you’ll have around 0.5 µV to play with. So, you’ll need a very high gain, extremely low-noise preamp. Use the transistor called out or another one designed specifically for low-noise, high-gain operation. This one runs a gain of around 1200 with a 0.5 dB noise figure at a 75-µA collector current. A shielded, temperature compensated, variable cup core is used for the collector load, tuned with a silver mica capacitor. One suitable cup is the #448-07-25 mH.

Costs around $4 from Caddell Burns Mfg Co., 40 East 2nd Street, Mineola, N.Y. 11501. A special #2103 tuning tool is $1 extra. The Q of this tank should be over 200 for proper noise reduction. Thus, the coil, the tuning capacitor, and any loading all get into the act. A Darlington emitter follower, using a superbeta transistor driving a plain one superimposes the signal onto the B+ line so you can drive 30–50 feet of shielded single-conductor cable. You power the preamp from a 9- or 10-volt supply. A 470-ohm dropping resistor and capacitor to demultiplex the other end. The supply line must be thoroughly bypassed to prevent any stray signals from getting into your receiver.

The output signal level should be over 100 microvolts in a poor area and up to 4 millivolts in a good one, getting the signal up big enough that we can handle it with ordinary IC’s.

To use the preamp, get it above all local metal and point it towards Fort Collins, Colorado, or clip the hole in the loop is pointing 90° away from Fort Collins. This is the optimum signal position, although turning it slightly from this might reject some directional local interference.

Hook up some supply power and look at the output with a sensitive 100-µV audio voltmeter, or add some raw gain and look at the output of your amplifier with a voltmeter. Unless you can get a reasonably legible, if somewhat noisy, signal, there’s no point in going any further. Try reading the code. Unless the preamp can get you at least a recognizable signal, there’s no hope for anything further down the line. Both the loop and the tank cup core should be tuned for maximum amplitude. Try rotating the loop 90° and see how far out of the noise the minimum signal is.

At this point, you should have a good idea of how rough the reception job will be. If it looks like you could arc weld with the signal—fine, a simple receiver is all you need. If the signal is barely identifiable, some more exotic techniques will do the job. If it’s not there, either you don’t have a working preamp, it’s daytime of an alternate Tuesday, or else the job is hopeless. Above all, don’t go beyond this point until you are confident you can get results. Total cost this far should be under $8.

A simple receiver

A National Semiconductors LM372 makes a dandy receiver. The IC has two sections—an initial agc stage which you can capillary couple to a high-gain stage and a detector. You should get several tenths of a volt of detected output signal, and you can monitor the output with a vvm. Be sure to have data sheets on this and all the other transistors and IC’s on hand when you are working with them. Also, if you attempt preamp tuning with the LM372 attached, don’t forget to defeat the agc or you won’t see your tuning peak. If you can get reliable results with this simple system, all you have to do is add a suitable comparator on the output to get 1’s and 0’s and then go straight to your decoder. The simplified receiver is shown in Fig. 5.

Some advanced techniques

At this point in the game, you either have a good signal, a marginal one or a worthless one. If it’s good, you’re done at low cost. If it’s a little marginal, maybe some of the tricks we’ll show you will be helpful. Which ones you want to use depends on what you want to spend in the way of time and effort and how close you are to reliable operation. Here’s a rundown of suggestions:

TECHNIQUE No. 1—Clip the impulse noise. Much of the interference will be caused by high-amplitude, high-energy spikes of short duty cycle many times the signal amplitude. If you can clip these off at twice the normal signal level, they won’t contribute nearly as much to problems later...
in the circuit. The limiter has to be inside the age loop, and the inside gain has to be adjusted so that limiting takes place at twice the normal signal level over the normal operating age range. Once set properly, the age will accommodate a reasonably wide range of signal levels without the clipping level moving around too much. It's absolutely essential that you limit the noise before further filtering or detection, for the impulse noise gets wider and lower with further processing. Thus you want to remove as much of the noise energy as soon as possible in the circuit. Fig. 6 shows an experimental circuit that includes the limiter with some of the other advanced techniques. The circuit includes the basic receiver and is used with the prepamp.

**TECHNIQUE No. 2—Watch how you reduce the bandwidth.** The way in which you end up with a final narrow-band detected signal can make a drastic difference. The effective noise bandwidth at the preamp with a Q of 200 is 60,000/200 or about 300 hertz. We need a final "video" bandwidth of around 3 hertz. Here's some facts of life on how we can pick up signal to noise ratio while we decrease bandwidth:

1. If you do your filtering after detection, you will only improve the signal-to-noise ratio by a factor of 50 which is slightly better than seven times or 7 power db better than the basic receiver.

2. If you do your filtering before detection, you will improve the signal-to-noise ratio by a factor of 50 which is much better than the basic receiver.

3. If you don't detect, but instead you multiply (autocorrelate) the signal with a limited version of itself and then filter, you also gain 7 times or 7 power db over the basic receiver. The filtering is now much cheaper, but the circuit more complex.

4. If you don't detect, but instead multiply the input signal (cross correlate) by a signal that looks like WWVB is supposed to and derived from an ultra narrow band phase-lock loop, you can do three power decibels or twice as good as in 2 or 3. The ultimate improvement is then 10 times or ten power decibels better than the simple receiver.

**By the way, the final "worst case" signal to noise ratio must be at least 14 db for error free code reception.**

We already went route 1 with the simple receiver of Fig. 5. For 2, all we need is a nice 6-Hz wide, temperature-stable, accurate 60,000 hertz filter. Lots of luck. We tried a bunch of very expensive ones, including quartz resonators, magnetotriestic stacks and ultrasonic filters. All of these worked but were too expensive. You might try several preamp circuits cascaded; this will reduce the signal bandwidth somewhat but probably won't be very cost effective and could cause oscillation and shielding problems. 60-kHz crystals have too high a Q, even if you let air into the air to damp them, although a pair of crystals properly stagger tuned probably would work. Again, it's not very cost effective.

For 3, use the limiter/multiplier, shown in Fig. 6, and you'll get good results. This IC is under $3. Make absolutely certain the limiter output is a noise-free square wave. Incidentally, this output also makes a reasonable precision frequency reference for lab work if it is hard limited.

This multiplication technique is not decoding. It translates the signal down to dc, and a filter following it acts just like a narrow band filter in the rf. Since both sidebands fold over, a 3 Hertz low pass output filter does the same job a 6 Hertz Bandpass RF one would.

For 4, you have to ask whether another 3 db is really worth all that effort. Anyway, a block diagram is shown in Fig. 7. First you build a varactor-trimmed crystal oscillator that runs within a few hertz of 60,000 Hertz. You build a phase detector and an integrator with a half-minute time constant, and critical loop damping. Full details are in Phase-lock Techniques by Floyd Gardner, published by John Wiley. Master the book before you start.

The theory of the phase lock loop says that you are reconstructing a replica of WWVB that averages out all the noise. When you multiply (cross correlate) this signal against the regular received WWVB, the signal you want gets translated down to dc. Noise that happens to be out of phase (in quadrature) with the signal gets cancelled, while noise gets reduced in proportion to its phase angle. The average statistical reduction of the noise is 3 dB, or 0.707. It probably isn't worth it, although you get an ultra-accurate, ultra-stable lab standard in the bargain. Note that IC phase lock loops are hopelessly inadequate for this job where the stability has to be measured in drift rates of cycles per minute.

**FIG. 8—LOW-PASS FILTER is used to filter the output. Gives a db or two of additional improvement.**
WHY THIS ARTICLE?
August 26, 1973 marks the 100th anniversary of the birth of Lee de Forest. And it is in recognition of the many contributions of this electronics pioneer that this article appears.

In this age of solid-state, after 25 years of the transistor, many of us are inclined to underestimate the importance of the fundamental invention of electronics, the vacuum tube. Yet before the 25 years of the transistor, we have had 40 years of the tube.

Indeed, if we had been forced to continue with the crude methods of transmission and reception of the pre-tube era, it is unlikely that radio communications would have developed enough to make the research that led to the transistor's invention possible.

So, as de Forest is acclaimed as the Father Of Radio, his vacuum tube can be considered the progenitor of the transistor—the father of solid state.

De Forest's most important invention has, unfortunately, overshadowed his other accomplishments, which would have made him probably the most important figure in American radio communications without it.

Most of the more important "wireless" stations now operating along the Atlantic coast were established by him. His "radio knife" of electronic surgical scalpel is well known in the medical field and our present talking movies follow very closely the principles of the de Forest Phonofilm.

by FRED SHUNAMAN
LEE DE FOREST—LIKE TOO MANY OTHER figures in the history of electronics—is already becoming a victim of neglect by those who write the histories of radio. Given the honorific "Father of Radio" for his invention of the Audion amplifying vacuum tube, practically none of his other work is mentioned—nor remembered. And illiterate historians—because of a superficial resemblance between the two devices—are prone to describe even de Forest's most important invention as a mere improvement on the Fleming valve rectifier. Yet—invention of the vacuum tube aside—de Forest was the prime figure in the development of radio communication in the United States.

Graduating from Sheffield Scientific School, Yale, in 1899, he had chosen for his Ph.D. thesis "The Reflection of Hertzian Waves from the Ends of Parallel Wires." Marconi was then demonstrating his equipment in England (where he was denounced by some as using the apparatus of Lodge), Popov was experimenting between his station at Kronstadt and ships of the Russian Navy, and Ducretet had sent signals from the Eiffel Tower in Paris to the Pantheon, 4 kilometers distant. Tesla had (in 1898!) actually demonstrated remote radio control in Madison Square Garden, New York City. There was enough "wireless" in the air to fire the imagination of the newly hatched Ph.D., and he immediately sought employment in the communications field, meanwhile starting to work on a detector of his own, which he called the Responder.

This first de Forest detector was patterned on a principle described by the German scientist Aschkinass. A drop of liquid (de Forest spent many weeks trying to find the perfect one) between two contacts carried current until the arrival of an electric wave. Then its resistance rose suddenly, due to the breakdown of "little trees and bridges" of metal in the liquid. Its great weakness was that after a time—ranging from minutes to days—it would "clog" and pass current continuously.

Working in Chicago, first for Western Electric, then part-time as assistant editor of the Western Electrician and receiving some support from a fellow-worker, Ed Smythe, de Forest brought the Responder to a point considered usable, and—jointly

The Audion—the vacuum tube triode; telephone dialer; and an electronic scalpel
100th Anniversary

The first radio signal jamming; an automatic are all the inventions of this man

with Smythe—took out a patent on it.

The famous “gas mantle” incident occurred during this period. Smythe and de Forest noted their spark discharge caused the gaslight to brighten, and devised an interesting theory to account for it. When they found it was simply the sound waves from the spark gap that caused the effect, de Forest refused to abandon the “ionized gas” theory. Finding that a gas flame was, indeed, a crude detector of wireless signals, he patented during the next several years some 11 devices using ionized gas, the last one being the Audion.

Having developed equipment that would work reliably over at least four miles, de Forest went East with the idea of covering the upcoming International Yacht Races by wireless for the Associated Press. But Marconi had already signed a contract with them. After some trouble, de Forest got a contract from the Publishers Press Association, loaded his equipment on a tug, and went out to write a new page in the history of wireless.

That new page was the discovery of interference. Both Marconi and de Forest had heard of tuning, but neither considered that refinement necessary. They jammed each other hopelessly, and the race reports were transmitted to shore—wirelessly, sure enough—by wig-wag flags.

De Forest in business

Organizing a small firm, the American Wireless Telegraph Co., to raise capital to improve his apparatus, de Forest struggled to keep alive through the rest of the year. In January 1902 he met the first of the “businessmen” destined to move the de Forest fortunes into affluence and bankruptcy not once, but three times. Abraham White was a highly successful professional promoter, who was convinced there was money in the glamorous wireless field. Not as critical as de Forest’s technical friends, he asked only that the equipment show up well enough to persuade investors to buy stock. Absorbing de Forest’s company, he formed the American de Forest Wireless Telegraph Co., and de Forest found himself with capital to work with—plus a regular salary of $30 a week!

His first development was an ac-operated spark transmitter, with a “high-frequency note” of 120 Hz, which produced a sharper and easier...

WHAT WAS THE AUDION, REALLY?

What actually was this Audion, de Forest’s most important invention? Was it—an as some say—simply an improvement on the Fleming valve (“de forest inserted a third electrode”) or was it an entirely separate invention?

The answer is that the Fleming valve and the de Forest Audion are not only two distinct inventions, but belong to two different families of detection devices. The Fleming valve is a rectifier. As such, it takes its place with Fessenden’s Wollaston detector and the crystal detectors of Pickard and Dunwoody. The de Forest Audion is a relay—a device that uses the radio signal to trigger or control a greater amount of power supplied by a local source (de Forest’s “B” battery). It belongs to the same family as the Brantly coherer and de Forest’s earlier Responder.

Because the Audion can control a greater amount of power with a smaller amount, it can amplify, and can also be made to regenerate. Oscillation and radio transmission are, of course, a product of that effect.

Dr. de Forest experimented for a number of years with devices fundamentally similar to the Audion, using the ionized gases of Bunsen burners. In 1904 he turned to partially evacuated lamp bulbs to produce the same ionization. It is quite possible that the idea of using a lamp bulb may have been suggested to him by the Fleming valve. It is equally possible that, since both were working with glass bulbs in 1904, they may have been working in ignorance of each other’s efforts.

But even if de Forest had known of Fleming’s valve, and (as an extreme case) had obtained one of them, opened it, placed his grid in it and resealed it, it would still have been in no sense a modification of nor an improvement on the Fleming valve, but a separate and independent invention. Lee de Forest was persuaded of the importance of ionized gas, found that a partly evacuated bulb gave him an opportunity to work with ionized gas. It was a more reliable and rugged device than his earlier open flame devices. Fleming’s rectification did not enter into his calculations—in fact one of his earliest patents on what we now know as the Audion was entitled “A Device for the Amplification of Feeble Currents.”
to-read signal than the low notes of the dc interrupters previously used. Then he set up stations in lower Manhattan and Staten Island, and exchanged messages between them. The Navy became interested, though continuing to depend in the main on German apparatus, which could print messages out on tape. They bought de Forest equipment, both for shipboard use and to outfit two new stations, one at Washington and one at Arlington. This kept the de Forest plant working full-time through the winter of 1902-03.

In 1903, de Forest finally succeeded in reporting the International Yacht Races by radio instead of light waves. 1903 also saw the introduction of wireless to Canada. The first press station, with which the Providence Journal kept in contact with Block Island, and the first commercial wireless telegraph—between Nome, Alaska, and Fort St. Michael, a distance of 107 miles—were also installed that year.

The year 1904 was even better, with de Forest's exhibit the main attraction of the St. Louis World's Fair, and a contract for five powerful Government stations—at San Juan, in Puerto Rico; Key West and Pensacola, Florida; Guantánamo, Cuba; and Colón, in the future Canal Zone.

In 1906 de Forest first ran afloat of his stock-selling associates. White and his pals gutted the company by organizing a new outfit, United Wireless, and transferring to it all the assets and none of the debts of the older company. Quitting the organization in disgust, de Forest turned in all his stock, asking nothing but the patents on the Audion and on the Aerophone, an arc telephone with which he had been experimenting, and $1,000 in cash.

The radiophone

Organizing the de Forest Radio Telephone Co., almost without capital, he moved into the Parker Building, New York City (now famous as the birthplace of the Audion) and started to make radio telephones. During 1907 and 1908 he installed equipment on two dozen Navy craft for a round-the-world cruise. Because of hurried installation and untrained operators, results were good only in odd cases, according to de Forest. But even these results persuaded Admiral Evans of the value of the radiophone, and he became a strong supporter of it.

In 1908 the Italian government bought four sets of equipment for use in warships, and a little later the British bought two, after tests showed reliable communication over more than 50 miles.

Amplification and regeneration

Working on a method of recording signals, de Forest found they were often too weak to be recorded properly. One of the earliest patents on the Audion was entitled "A Means for Amplifying Feeble Currents," and with two assistants, Charles Logwood and Herbert van Etten, de Forest set about to make it earn the title. But the Audions of that day would glow blue and stop amplifying if more than a few volts were applied to the plate. Realizing that the trouble was probably too much gas (de Forest was still sure that some gas was necessary for Audion action) he had a local X-ray manufacturer evacuate some tubes to a higher vacuum. The new Audions would take 120 volts, and were immediately successful as amplifiers.

While working on the amplifier, de Forest and his assistants one day connected the output of the second stage back to the first. That historic day, August 16, 1912, was the birthday of feedback, regeneration and oscillation. They heard (and described in van Etten's notebook) a high musical note as a result of the feedback experiment, and noted that it could be varied by varying the capacitance or inductance in the circuit. Further experiments—one a day when only one good Audion was available—showed that the same results could be obtained with a single tube—self-regeneration or oscillation.

Years later, when Armstrong claimed the invention of regeneration, van Etten's notebook was the instrument that proved de Forest's priority.

De Forest decided to go East and demonstrate his new amplifier to "The Telephone Company" (AT&T and its subsidiary Western Electric) who had long been searching for a way to boost signals on long-distance telephone lines. He was encouraged by the attitude of the Telephone Co. and decided to remain East. But after nearly a year of waiting, with no money coming in from the North American Wireless Corp., de Forest found himself literally broke, with his watch in pawn.

At this time he was approached by a young lawyer, Sidney Meyers by name, who said he represented parties interested in the Audion as an amplifier. He would not reveal his backer, only pledging his "word of honor as a gentleman," that he did not represent the Telephone Co. He offered $50,000, a much smaller sum than de Forest thought he could get for the amplifier rights. But his company, owner of the patents, was in a precarious position and might find company assets, including the patents, put up at auction to satisfy creditors. And de Forest himself was on the verge of starvation. So he agreed, only to find a few weeks later that his customer was indeed the Telephone Co., and that its directors had allegedly been prepared to pay as much as half a million dollars for the rights he sold for $50,000.

The deal was not as bad as it has been represented; de Forest did not sell the Audion patent—simply the right to use it as an audio amplifier on wire lines.
claimed it would soon be possible to send the human voice across the Atlantic with what the prosecutor described as “a queer little tube that had proved worthless—not even a good lamp!”

In 1914 de Forest ran into new legal trouble. The Marconi Co. charged that the Audion infringed the Fleming valve patent, and won the case. But the court also decided that the Audion patent was valid as well. The result was that neither de Forest nor Marconi could make Audions. The resulting confusion lasted until the Fleming patent expired in 1922, and produced some absurd effects. For example, Marconi had licensed the Moorehead Co. in San Francisco to make Fleming valves. So de Forest’s company ordered Audions from Moorehead, and sold some to Marconi!

Also in 1914, Sidney Meyers appeared again—in the open this time. The Telephone Company was interested, he said, in securing radio signalling rights in the Audion, and offered $10,000 for such rights. More cautious this time, de Forest asked for $100,000, and obtained $90,000. The de Forest company retained the right to manufacture Audions “for amateur and experimental use.”

In 1915 de Forest used the Audion to make the first music synthesizer, selling the patent to Wurlitzer.

Broadcasting established

In the winter of 1909-1910 de Forest had pioneered broadcasting by putting the Metropolitan Opera on the air—for one performance. Now he began a regular broadcast service from his High Bridge station. Because he transmitted phonograph records, lent by Columbia, he claims the title of world’s first disc jockey. He also became public pay, plus rights in all patents pending and to be filed during the next seven years. The price was $250,000. The de Forest Radio Telephone and Telegraph Co. retained foreign and government rights.

This deal has not been nearly as well publicized as the first one. All in all, instead of $50,000, de Forest received $390,000 for the Audion and developments based on it.

Broadcasting from High Bridge started again after the war, and de Forest moved his station to midtown Manhattan, where he had access to a better antenna. The number of listeners had swelled “into the hundreds” when the station was closed by the Federal radio inspector, Arthur Bachelor. The legal reason was that the station had changed location without a permit, but Mr. Bachelor made it clear that interference with commercial radio stations would not be tolerated, and that “there is no room in the ether for entertainment.”

De Forest Phonofilm

De Forest next turned to the movie sound field. He had already experimented with magnetic wire recordings synchronized with the film, but now decided to try to put the sound on the film itself. The world’s first talking picture, a Swedish film called “Retribution” in translation, was produced by de Forest Phonofilm in 1925. Phonofilm had some 34 theaters “Wired for sound” at that time, but competition was strong and the movie moguls moved to another system. He retired from the field in 1929, with only $60,000 as a settlement from one of his commercial and legal competitors.

To get capital for his sound-on-film work, he sold control of the de Forest Radiophone and Telegraph Co. to a group of Detroit automobile capitalists. He was hired by them as a consulting engineer, and was able to watch the company go downhill to ultimate absorption by RCA. Thus the last of the de Forest companies—like the first—finally became part of RCA.

The busy period of de Forest’s life ended with sound-on-film. In the ’30’s and ’40’s, he experimented with television, devising a color filter hardly larger than the tube screen, instead of the bulky and alarming color wheel.

In his work with television he also developed his last important invention, radial scanning, patented in 1941. He disposed of the patent to RCA, at a lower price, he said, than he would have if he could have foreseen radar (only a year or so later) and the PPI display.

Continuing to experiment and invent, he again found himself not oversupplied with funds. A contract entered into in the ’40’s with the Bell Telephone Laboratories supplied him with means to equip a new laboratory and eased his financial situation considerably. In return, he was to license Bell under all patents that might be granted him.

Dr. de Forest remained more or less active until his retirement in 1958, when he was 84 years old. His last patent—an automatic telephone dialing device—was issued in 1957. He went to France the same year, to receive the Cross of the Legion of Honor, which was added to a number of earlier honors, including the degree of Doctor of Science from both Yale and Syracuse universities, and awards from various learned institutions and organizations. He died June 30, 1961, after a long illness

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THE DEVELOPMENT OF A NEW AND unique semiconductor imaging device using a novel principle known as charge-coupling was announced by scientists and engineers of the Bell Telephone Laboratories (Murray Hill, N.J.) during the first quarter of 1971. Writing at the time, I predicted that commercial devices based on this new principle "probably will not be available . . . for many months." Nearly 24 months later, that prediction has now been fulfilled by Fairchild's Semiconductor Components Group (464 Ellis Street, Mountain View, Calif. 94040) with their recent announcement of the industry's first commercial charge-coupled device (or CCD), a 1 x 500-element image sensor.

Illustrated in Fig. 1, Fairchild's new CCD is a linear array comprising 500 photosensitive elements sealed under an anti-reflective glass window in the center of a 24-pin DIP measuring only 0.6 x 1.3 inches. The monolithic n-channel device also includes two charge-transfer gates, two 250-element CCD analog shift registers, a two-element CCD selection register and an on-chip NMOS output amplifier.

Photosensor elements are spaced on 1.2-mil centers, and the shift register elements are on a 2.4-mil spacing. The new device has a typical dynamic range of 1,000:1, combining this capability with a high sensitivity of 15 microfootcandle seconds.

Fairchild has used a buried-channel structure and poly-silicon gate technology in producing its new device, as shown in the cross-section sketch. Fig. 2. Poly-silicon is transparent to visible and near-infrared light, thus assuring maximum efficiency. A thin n-type donor layer implanted between the oxide dielectric and the silicon substrate forms a transfer channel that is isolated from the oxide-substrate interface, thus eliminating the trapping effects caused by surface states in other types of charge-coupled designs, and resulting in increased transfer efficiency and greatly enhanced image integrity.

The physical layout of the image sensor's circuit components and con-
Control functions are illustrated in the photomicrograph, Fig. 3, while circuit connections are identified in the corresponding schematic, Fig. 4.

In operation, light striking the photosensitive elements in the thin center strip are collected as individual charge packets proportional to the amount of light at each element. These charge packets then are transferred to one of the 250-element, three-phase charge-coupled shift registers at either side of the photo gate.

Alternate charge packets are simultaneously moved to the left and right shift registers. The packets are then transferred vertically through the shift registers to a two-element horizontal selection register which inter-leaves alternate packets from the left and right vertical registers to restore the proper sequence of image elements and feeds them to an output gate. This gate then feeds the image signal sequentially into an NMOS output amplifier which, in turn, delivers an output electrical signal representing the scanned light image on the photosensitive elements.

Fairchild's new 500-element linear array is intended for use in slow-scan TV systems, document reading, optical character recognition and similar high-sensitivity imaging applications, including military reconnaissance and weapons systems. Current stock availability and pricing information on the new image sensor may be obtained directly from Fairchild or its authorized distributors and representatives.

The lit bit

One of our best sources of information concerning new device applications is the literature published by semiconductor manufacturers. Despite their value and expense of preparation, these publications often are available either free or for a nominal charge.

Depending on the product and the publisher, individual publications may range from single page specification sheets to multi-page design brochures and even to thick hard-bound handbooks. In addition to basic design information, these publications frequently include complete project schematic diagrams and circuit construction hints.

The practical 28 volt switching regulator circuit illustrated in Fig. 5 is typical of the information given in some manufacturers' literature. Abstracted from Application Note 49, published by the Delco Electronics Division (General Motors Corporation, Kokomo, Ind. 46901), the design features a type DTS 1020 npn Darlington silicon power transistor. According to Delco's 4-page application note, the circuit will furnish 28 volts dc at loads of up to 100 watts when supplied by sources of from 22 to 28 volts dc. Its output regulation and ripple are less than 1% at full output.

Aside from its general performance specifications, the design's most interesting feature is its ability to furnish a regulated output voltage higher than its supply voltage (28 volts out with 22 volts input) without using conventional dc-to-dc inverter circuitry and a step-up transformer.

In operation, this is achieved by the flyback action of the 0.4 mH series choke when switched at a 9 kHz rate. Voltage regulation is accomplished by sensing the circuit's output voltage and using this for pulse-width modulation of the signal used to drive the Darlington switch. A UJT relaxation oscillator serves as the basic 9 kHz signal source.

Delco's complete application note includes not only the circuit diagram, but basic design mathematics, a discussion of circuit theory, performance curves, all parts values, and even winding details for assembling a suitable choke.

A number of useful publications are available from the Sprague Products Co. (North Adams, Mass. 01247), including a 50-page Semiconductor Replacement Manual, Manual K-500, a 40-page IC catalog, and a new series of LED Application Notes, publications SPAN-1A through SPAN-6.

Basic specifications and outline drawings of the 82 general purpose semiconductor devices in Sprague's Q-Line are provided in Manual K-500, together with replacement cross-references to over 30,000 standard industry type numbers. In addition, the manual includes a number of valuable guidelines covering semiconductor replacement techniques.

Entitled Sprague Integrated and Thin-Film Hybrid Circuits, Short-Form Catalog WR-125F covers the firm's...
Featuring a down-to-earth "how to" approach, Sprague's series of LED Application Notes should be of particular interest to practical engineers, technicians, and hobbyists. Starting with a discussion of LED power requirements in SPAN-1A, the notes cover such topics as a BCD simulator, the assembly of a seconds timer, device interfacing, and semiconductor relays. SPAN-4, typically, describes an inexpensive LED voltage and continuity tester, illustrated in Fig. 6, which is suitable for many automotive, marine, and household maintenance tests.

Working with FET's? Then you should check with Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, Calif. 95054), for this firm offers a number of superb application notes dealing with these versatile devices. Recent releases include the 16-page FET's As Voltage-Controlled Resistors and the 12-page FET's As Analog Switches.

If microwaves are your bag, you'll want to check with RCA's Solid State Division (Box 3200, Somerville, NJ 08876). RF and Microwave Devices, publication RFT-700K, is an 8-page brochure which includes a quick-selection guide showing power-vs-frequency curves for RCA's entire product line, with power levels to 80 watts and frequencies to 3.5 GHz; block diagrams illustrate typical circuit applications, while photographs show all package styles.

Application Note AN-6084, High-Power Transistor Microwave Oscillators, describes a simplified approach to the design of transistor microwave power oscillators with outputs of from 1 to 10 watts at L- and S-band frequencies; a number of practical circuits are included in the brochure. Broadband push-pull rf amplifiers are discussed in Application Note AN-6126, 60- and 100-watt Broadband (225-to-400 MHz) Push-Pull RF Amplifiers Using RCA-2N6105 VHF/UHF Power Transistors; AN-6126 contains schematic diagrams, performance characteristics and photographs of the amplifiers described. Finally, Application Note AN-6118, 10-, 16-, 30- and 60-Watt Broadband (1200- to 960 MHz) Power Amplifiers Using the RCA-2N6266 and 2N6267 Microwave Power Transistors, discusses basic broadband circuit design.

Texas Instruments, Inc. (P.O. Box 5012, Dallas, Tex. 75222) has released a number of interesting publications recently, including a simplified guide to JAN IC's, a new TTL IC data book, and an applications report on using dual-gate MOSFET's for TV.

Product/device news

Suitable for use as a photocell amplifier as well as for other general applications, the 3542J (Fig. 7) is a new low-cost op amp recently introduced by the Burr-Brown Research Corporation (International Airport Industrial Park, Tucson, Ariz. 85706). Offered in a hermetically sealed TO-99 package, the unit is pin compatible with the familiar 741 type op amps. It features a high impedance monolithic FET input stage, hybrid/thin-film construction, and a maximum voltage drift of only ±50 µV/°C. With a minimum dc voltage gain of 88 dB, the 3542J has a full-power frequency response of 8 kHz. When operated on a ±15 volt dc supply, the new device has a rated output impedance of 75 ohms, and can supply ±10 volts at ±10 mA. Both output short-circuit and input-supply-voltage protection are provided in the circuit.

RCA's Solid State Division, in addition to releasing a number of valuable new application notes, has outdone itself with the introduction of a number of new semiconductor devices, including the following:

A new linear IC dual high-frequency differential amplifier for low-power applications up to 500 MHz. This new device, type CA3102E, consists of two independent differential amplifiers with associated constant-current transistors on a common monolithic substrate. The six transistors comprising the amplifiers are general-purpose devices which exhibit low 1/f noise and a gain bandwidth product in excess of 1 GHz.

A new multi-purpose 7-ampere, low distortion, 100-watt, linear operational amplifier. Assigned developmental type No. TA8651A, this new power hybrid circuit is intended for use in high-fidelity audio applications requiring very low distortion (less than 0.1% IMD at 50 mW), and is also recommended for use in such applications as servo amplifiers, PA systems, voltage regulators, driven inverters, and power operational amplifiers. The device's output section can be externally biased Class AB for low intermodulation (0.05% at 50 mW) and low total harmonic distortion, while terminals are available for external frequency compensation, external short-circuit protection, and inverting and non-inverting inputs. As shown in Fig. 8, the TA8651A is supplied in a special compact multi-lead hermetic package.

Two new plastic-packaged Versawatt 6-ampere silicon triacs designed for the control of ac loads in such applications as motor and heating controls, relay replacement, solenoid drivers, static switching, and power-switching systems. Identified as types 40104 and 40105, they are similar to the popular 8-ampere 40669 series, introduced in 1968. Both are gate-controlled full-wave ac switches in plastic cases with three leads to facilitate mounting on printed circuit boards. They have on-state current ratings of 6 amperes at a case temperature of 80°C., peak surge full-cycle ratings of 60 amperes, and repetitive off-state voltage ratings of 200 volts (40104) and 400 volts (40105).

Four new epitaxial silicon npn planar power switching transistors designed for aerospace applications in which the devices might be subjected to extreme neutron and gamma-ray exposure. Designated types TA8007, TA8007B, TA8100 and TA8100B, these devices are intended for use in 5- and 10-ampere high-frequency power inverter service. All types utilize a flat, cylindrical package.
STEREO FM BROADCASTING BEGAN back in 1961. Since then, most stereo FM tuners and receivers have used either of two basic decoder circuits to recover independent left and right channel program information.

The standard stereo composite signal consists of left-plus-right program content which modulates the main carrier much as a monophonic program would. In addition, left-minus-right information, amplitude modulates a 38-kHz super-audible subcarrier which is subsequently suppressed. Only the lower and upper sidebands of this modulation are used to further modulate the main FM station carrier. Finally, a constant amplitude 19-kHz super-audible tone, having a fixed phase relationship to the suppressed 38-kHz subcarrier is used to modulate the main carrier to about 10% of total modulation. This 19-kHz signal enables the receiver circuitry to reconstitute the “missing” 38-kHz subcarrier so that the “difference” (L-R) signal can be demodulated in a distortion-free manner.

Remember, the L-R program amplitude modulates the 38-kHz subcarrier, but the resulting sidebands, sum information (L+R) and 19-kHz “pilot tone” all frequency modulate the main station frequency. The spectrum distribution of this entire composite signal is shown in Fig. 1. An SCA subcarrier, used to transmit private, subscriber background music such as you have heard in hotel lobbies, restaurants and other public places, has been added.

The suppressed-carrier sidebands attain their instantaneous peak values when the main-channel audio “goes through zero” amplitude (the principle is called interleaving). This makes it possible for both the sidebands and the L+R information to modulate the main carrier to 80% of full modulation, leaving 10% for the pilot tone and another 10% for the SCA (background music) service. When the SCA service is not used, both L+R and sidebands are permitted to modulate up to 90% each, leaving 10% for the necessary pilot tone.

The most obvious kind of circuit that might be used to recover left and right program information is in Fig. 2. The sum and difference signals are recovered separately, through complex low-pass and band-pass filters. A local oscillator, synchronized to the incoming 19-kHz pilot signal, drives a doubler to provide the necessary 38-kHz “subcarrier restoration. The difference L-R information is then AM detected and re-matrixed with the recovered L+R to form “L” and “R” signals.

The phase and amplitude requirements of this type of demodulator are so critical that it was soon abandoned. It can be shown mathematically that an overall phase shift of as little as 26 degrees between the 38-kHz subcarrier and the 38-kHz sidebands will result in a degradation of stereo separation down to 26 dB. With all those coils and capacitors in the filter and oscillator circuits, that means only a few degrees of phase shift error in each could easily degrade stereo separation to even poorer values.

A somewhat simpler circuit, known as a “time division” demodulator or a “switching circuit” demodulator is shown in Fig. 3. The number of tuned circuits required has been reduced since the entire composite signal is now fed to the “switching detectors”, but the conventional oscillator and doubler are still present and subject to phase errors, mis-tuning and drift. Phase errors in this circuit and in the circuit of Fig. 2 tend to become more severe when the desired “L” or “R” signal is a high audio frequency, since the sidebands then involved are further and further apart, bordering on the limits of the “passband”, where phase shift is greatest. (A 10-kHz audio signal will produce sidebands at 28 kHz and 48 kHz about the reconstituted 38 kHz subcarrier).

If an SCA rejection filter is added to this circuit (as indeed it must be, if SCA program interference is to be avoided), the added tuned circuit makes the situation much worse. It has been calculated that the permissible mis-tuning of the 19-kHz coil is only 30 Hz and that of the 38-kHz coil is only 120 Hz if satisfactory separation is to be maintained. Even if the original alignment of the circuitry is that good, the slightest jarring of the
set, temperature variation, or even aging can easily "detune" these coils by that much and even more.

**The phase-locked loop**

A phase-locked loop is basically a feedback circuit which consists of a phase comparator, a low-pass filter and an error amplifier in the forward signal path and a voltage-controlled oscillator (VCO) in the feedback path. A block diagram of the phase-locked loop in its most basic form is shown in Fig. 4. With no signal applied to the system, the error voltage $V_e$ is zero. The VCO operates at a set frequency, $\omega_0$, which is known as the free-running frequency. If an input signal is applied, the phase comparator compares the phase and frequency of the input with the VCO frequency and generates an error voltage $V_e$ that is related to the phase and frequency difference between the two signals. This error voltage is amplified, filtered, and applied to the control terminal of the VCO, forcing the VCO frequency to vary in a direction that reduces the frequency difference between $\omega_0$ and the input signal. If the input signal frequency is close enough to $\omega_0$, the feedback nature of the phase-locked loop causes the VCO to synchronize or lock with the incoming signal. Once in lock, the VCO frequency is identical to the input signal except for a small finite but constant phase difference necessary to generate the corrective error voltage which shifts the VCO frequency from its free-running value to the input signal frequency and keeps the phase-locked loop in lock.

**RCA's IC stereo decoder**

The first company to incorporate the phase-locked loop principle in a single, complex integrated circuit designed to do the entire stereo FM decoding job was RCA, and a block diagram of their CA-3090 IC is shown in Fig. 5. Subcarrier regeneration is handled by a phase-locked loop (PLL) circuit made up of a VCO operating at 76 kHz, a series of flip-flops to obtain the required signals needed in the system, and a synchronous detector whose dc output is proportional to the phase angle between the frequency divider output and the incoming 19-kHz pilot signal.

The VCO used in the circuit is an LC oscillator and therefore requires one external coil. RCA decided to use a frequency of 76 kHz rather than 38 kHz to insure that the reinserted 38-kHz carrier is perfectly symmetrical, because any loss of symmetry would impair audio channel separation. By starting at 76 kHz and dividing by two to get the required 38 kHz, symmetry is guaranteed.

Because the output of the phase-lock detector is zero, either when the frequency of the oscillator is correct or when there is no 19 kHz pilot (no stereo is being broadcast), an extra detector—the pilot presence detector—is needed to signal the presence of a stereo broadcast. The output from the frequency divider is in phase with the pilot signal and will, therefore, provide a signal to the mono-stereo switch to enable stereo reception. External components connected to pins 6, 7 and 8 set the threshold sensitivity and time constant of this detector. This filtering, along with the hysteresis action of the stereo-mono switch (Schmitt trigger) circuit, eliminates all flicker of the stereo indicator lamp.

The L-R (difference audio) synchronous detector is a doubly balanced detector and the composite signal fed to it is carefully kept as nearly distortion-free as possible, to preserve both fidelity and SCA rejection. The outputs of the L-R detector are added to the composite signal in summing networks where precisely matched resistors (in the block labelled "matrix") provide the proper voltage ratios.

A circuit detail of one channel of the matrix arrangement is shown in
output and IC input. Table I, condensed from RCA's data sheet, summarizes important performance data which may be expected when this unit is used with a reasonably good FM tuner or receiver. Having experimented with the IC myself, I can attest to the separation figures which are essentially maintained all the way up to 10 kHz audio or better.

**Motorola's inductorless IC**

A few months after RCA's introduction of their CA-3090 chip, Motorola introduced a stereo decoder IC which required absolutely no coils. Instead of an L-C tuned circuit oscillator, an R-C type of oscillator circuit is used. As shown in Fig. 7, only a few external resistors and capacitors are required to complete the circuit, and frequency "lock-in" is done by setting potentiometer R5, which forms part of the 76-kHz vco oscillator circuit. In addition to the fact that all inductors have been eliminated, some of the other performance parameters are very impressive indeed, as summarized in Table II. Separation, for example, is maintained at over 40 dB all the way up to 10 kHz and above, as

![Diagram](image-url)
shown by the curve in Fig. 8.

The superior performance of this new IC has prompted several high-fidelity component manufacturers to incorporate it in their new products for 1973-4, and an example of such a new product is Heath's AJ1510 digital stereo tuner shown in the photo on the first page of this article.

A complete block diagram of the layout of this IC is shown in Fig. 9. The upper line of circuit blocks are involved in the 38 kHz subcarrier regeneration process. An internal oscillator, running at 76 kHz, feeds its output to two divider stages, returning a 19-kHz signal to the input modulator. There, the returned 19-kHz signal is compared with the incoming pilot signal so that when a 19-kHz stereo pilot is received a dc component is produced. This dc component is extracted by the low-pass filter and used to control the frequency of the internal oscillator which ultimately becomes phase-locked to the pilot tone, in much the same way as was true of the earlier RCA chip.

The decoder section is actually a modulator in which the incoming signal is multiplied by the regenerated 38-kHz signal to produce L and R outputs. It is therefore analogous to the "time division" approach shown in Fig. 3.

The reconstituted 38-kHz signal is fed to the stereo decoder block via an internal stereo switch. This switch closes when a sufficiently large 19-kHz pilot tone is received. The 19-kHz signal returned to the 38-kHz loop is in quadrature with the 19-kHz pilot tone when the loop is "locked." A third frequency divider shown in the lower line of blocks is connected to produce (continued on page 88)

**R-E's substitution guide for replacement transistors**

**PART VI**

compiled by ROBERT & ELIZABETH SCOTT

R-E's Transistor Substitution Guide is a compilation of material abstracted from the substitution guides of eight leading semiconductor manufacturers and distributors. These are:

ARCH—"Indicates the Archer brand of semiconductors sold only by Radio Shack and Allied Radio stores. Allied Radio Shack, 2725 W. 7th St., Ft. Worth, Texas 76107

G-E—General Electric Co., Tube Product Div., Owensboro, Ky. 42301

ICC—International Components, Div. of IESC, 10 Daniel Street, Farmingdale, N.Y. 11735

IR—International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245

MAL—Malloy Distributor Products Co., 101 S. Parker, Indianapolis, Ind. 46201

MOT—Motorola Semiconductors, Box 2963, Phoenix, Ariz. 85036

RCA—RCA Electronic Components, Harrison, N.J. 07029

SYP—Sprague Products Co., 65 Marshall St., North Adams, Mass. 01247

SYL—Sylvania Electric Corp., 100 1st Ave., Waltham, Mass. 02154

Radio-Electronics has done its utmost to insure that the listings in this directory are as accurate and reliable as possible; however, no responsibility is assumed by Radio-Electronics for its use. We have used the latest manufacturers material available to us and have asked each manufacturer to cover the listing to check its accuracy. Where we have been supplied with corrections, we have updated the listing to include them. The first part of this Guide appeared in March 1973.
trapping the
creeper

A case of grid emission
at its worst

JACK DARR
SERVICE EDITOR

R-E's Service Clinic

ONE OF THE MOST MYSTERIOUS TROUBLES in horizontal output stages is "The Creeper." The set plays perfectly when first turned on. Then, the cathode current of the horizontal output tube starts creeping up, and up, and finally Click; out goes the circuit-breaker or the flyback, if the set doesn't have the proper protection. In most cases, the raster will pull in, dim, lose focus and gradually disappear.

What causes this? In most sets the standard tests will show no high leakage, or similar problems, in any of the numerous "loads" on this circuit. By loads, I mean the high voltage, boost, boost-boost, sweep and focus. In some, all tubes will be new. So, what in Tunket can cause such a symptom?

There are quite a few suspects. Normal suspects, that is. For one, a gradual loss of grid-drive signal. If the horizontal oscillator is weak, and the peak-to-peak voltage of the drive gradually falls off, you'd see the same symptom. With low drive, the grid voltage of the output tube goes more positive, and cathode current goes up. This voltage is developed by grid-leak action in the horizontal output tube's grid circuit.

A slight leakage in the coupling capacitor might be a good suspect. However, capacitor leakage is more or less fixed, and won't show the creep symptom. They're seldom thermal, too. But don't take chances, check it anyhow.

Another handy-dandy cause for this is the grid-bias control type of high-voltage hold-down circuit. These things use a pulse from the flyback, fed into a diode in the horizontal output tube's grid return circuit. When the output goes up, the pulse amplitude increases. This is rectified, and converted into a higher negative bias for the output tube, holding down its output. There are usually several high-value resistors used in this circuit, always a good suspect for thermal drift. Diode leakage, too, could do it, although this is rare.

All of these are more or less "normal" causes, and we check them as a matter of course. However, a new one has been cropping up of late, and I thought it would be a very good idea to bring this out. It can be identified immediately, by a very simple test, if you know about it. (To be frank about it, I discovered it while looking for something else.

The basic fault is grid emission in the horizontal output tube! When this happens, the tube starts drawing grid current. This makes the grid go more negative, due to the grid-current flow through the high-value grid resistor. So instead of conducting for the proper amount of time (which is very short, something like 8 to 10 μs), the tube stays on longer. This increases the pulse width, and conduction time and with it the average cathode current. This phenomenon is definitely thermal; the longer the tube operates, the greater the grid emission and the greater the heat dissipation.

The "simple test!? Just hang a scope probe on the control grid of the horizontal output tube, and watch the waveform. The normal waveform is like Fig. 1-a, with a nice sharp peak. When this fault develops, you'll see this peak gradually start to flatten out, as in Fig. 1-b. Even a flattening of this much can raise the cathode current quite a bit. When it has flattened to something like Fig. 1-c, your cathode current will be up around 400 mA, and the breaker had better be getting ready to trip. The equivalent pulse-widths are shown below, so you can see why it acts like this.

The cure? Simple; another new tube. Cook the set, with the scope still on the grid, and the meter in the cathode. In one of the first cases I ran into, a brand new set showed these symptoms. The horizontal output tube was replaced, only to find exactly the same trouble. A third new tube turned out to be good. The first two were checked on a tube-tester capable of reading grid-emission, and showed a
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RCA

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very high reading. Their emission was good, of course; any tube that can draw 400 mA current is in good shape in that department.

This problem doesn't seem to be confined to any particular tube-type. I first ran across it a couple of years ago, in a 6LQ6. Since then, I've seen it in 6LQ6's, 311Z6's and so on. So, if you find a creeper, scope the horizontal output tube grid, with the centermeter in the cathode, and wait.

This applies to tube and hybrid sets, of course. However, you can see a very similar symptom in solid-state sets. This seems to be due to thermal runaway, or its equivalent, excess junction leakage. This is almost always thermal, and the leakage grows progressively worse as the set plays. Read the current drain, and scope the base of the output transistor, to make sure that the drive pulses are of the correct width. They're different in shape to those of tube sets, but the basic principle is still the same. If the pulse-width stays the same, try replacing the horizontal output transistor. R-E

reader questions

HORIZONTAL OSCILLATOR SETUP

There are four or five pictures across the screen of this RCA KCS-130 chassis. I've changed the oscillator tube, and the stabilizer coil, and it still won't sync.—J.B., FPO, N.Y.

This chassis uses a variation of RCA's famous Synchroguide circuit, and must be set up using the factory procedures, or it won't work properly. Try this: 1. Connect a jumper across the terminals of the sinewave coil. 2. Ground the grid of the sync output tube; pin 9 of the 6EA8, on the same PC board with the oscillator. 3. Adjust the horizontal hold control until you can see only one picture. This will float from side to side, but if it will stand still for even a moment, fine. This means that the oscillator is able to free-wheel.

4. Take the jumper off the sinewave coil. If the picture falls out of sync, adjust the core of the sinewave coil until it locks in again. There's still no sync, remember; so, the picture will float; get the sides of the picture straight, and it should hold fairly still. Shorting the sinewave coil should cause only a small sidewise shift.

Final step: take the short off the sync-tube grid, and the picture should lock in very firmly. Change channels and see; it should snap in, in horizontal sync, instantly, if it's working properly.

MIDDLE-STRETCH IN RASTER

This is a new one on me. I've seen pictures stretch at top or bottom, but never seen one stretch in the middle. What causes this?—M.P., Del Rio, Tex.

Most likely cause, the deflection yoke. Frankly, I don't know the exact nature of this defect, but I've cleared up quite a few cases of it by replacing the deflection yoke. Probably some odd short.

NOT ENOUGH WIDTH

I replaced the deflection yoke in this GE M-760-C WD, and got the raster back. Works fine now, but I don't have enough width. Need about an inch on each side. Width control doesn't help. I have a bad hum on all channels, too.—W.P., Carolina P.R.

Two possibilities here. One, low dc supply voltage due to a bad electrolytic in the voltage doubler. This could reduce the width and cause the hum all at the same time. Check dc voltages at power supply. Normal +300 V.

No. 2: if the width control doesn't have any effect when you move the core, it could easily be shorted. For a
fast check, just disconnect it. If this brings back the width, replace the width control. (The hum probably be due to an open filter capacitor or a heater-cathode short in audio tube, etc.)

MAKING IC SOCKETS; REMOVAL
You can buy lots of “boards”, and things with IC’s on them, dirt cheap. The only problem is getting them off the boards without overheating them. Also, how can you make good IC sockets?—R.J., Antioch, Ill.

First, I’d use a low-wattage de-soldering iron, and clear out only 2-3 pins at a time. Let it cool between times. Or, spray coolant on the IC itself, as you work. (This could get to be a three-handed job, of course.) Or: clip a heat-sink on the IC while taking it out.

Second, you can get the “strip” contacts, for making IC sockets, from several places. They’re made by Mollex, and are sold at about 100 for $1.00. They can be soldered into the holes of a PC board, to make a pretty darn good IC socket. You’ll find these used on Zenith modules using IC’s, and others.

NOISE IN GE “PORTA-FI”
They brought in a GE receiver unit, and called it a “Porta-FI”. Works with a big console stereo, and picks up the music, etc. Never ran into one before.

Anyhow, it works, but it’s very noisy. Has a loud harsh buzz. Turn volume down, no buzz. I’m puzzled.—J.M., Donora, Pa.

Un-puzzle. This is a “carrier-current” device, like a wireless intercom. The transmitter, in the console, generates a low-frequency rf signal, which is carried to the receiver over the ac power lines. Works on one of two channels, 250 or 300 kHz.

Your buzz could easily be unfiltered fluorescent lights, or SCR light dimmers, etc. Turn them off and see if this stops the noise. If so, filter them, not the receiver unit.

Alternative: the receiver unit may not be correctly tuned to the transmitter. Normally, the receiver should “quiet” a good deal with a strong carrier.

MANY, MANY SYMPTOMS
I never saw a color TV set with so many different symptoms! The horizontal sync is very, the age won't work, the colors drift, and you name it. This is an RCA CTC-38 chassis. Any ideas as to what causes this?—R.D., Smackover, Ark.

With so many symptoms all at the same time, the most likely suspect would be something that is common to all circuits. The dc power supply. If one of the filter capacitors has opened, it will allow a heavy feedback through the power supply, and upset everything for three feet in all directions.

One frequent offender in these chassis has been the 20-µF electrolytic on the +40V line. Check this with a scope. One showed 35 volts p-p ripple, and very similar symptoms.

TUNER TROUBLE
I can get an i.f. signal through from the input, and see good clear bars on the screen. No stations from the antenna. I suspect the tuner. Right?—R.B.M., Miami, Fla.

Right! Most likely suspect, one of the transistors in the tuner. Check for correct dc voltages, and especially for correct or nearly correct emitter voltages. If you find one with collector and base voltages close, but no emitter voltage, that’s the one. Transistor probably open.

Some transistors used in this series of tuners are not the “BEC” basing shown on the schematic. Check with magnifying glass. May be “EBC”

BREAKER POPS WITH GOOD DIODE
Here’s a weird one! If I remove diode D1 in this Admiral 51110 chassis, the set works; good high voltage and focus. If I put D1 back in, the breaker trips. Even if I take off the loads, and unhook the degaussing coil, it still does it. What is this?—M.H., Del Rio, Tex.

Check that thermal switch. I think you’ll find it is grounded, or stuck closed. Certainly, something is causing this, and that’s the only thing left outside of the bridge rectifier itself.

HORIZONTAL HOLD AFFECTS COLOR
When I turn the horizontal hold control on this Zenith 5320 one way, colors get brighter. Turn it the other way, and they get lighter. Why?—J.F., Munhall, Pa.

This effect is seen in some chassis, and it’s perfectly normal. The color burst, sync, acc, and several other things, are “gated on” by the horizontal pulse coming from the flyback. (Not by the horizontal sync pulse ex-
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tracted from the incoming signal!)

When you turn the horizontal hold control, you “move” this pulse. In effect, you change the phase with respect to the horizontal sync from the signal. So you shift the acc, you may clip off part of the color-burst, and so on. Horizontal hold control on these sets must be adjusted exactly in the middle of its range, so the set will not lose sync when the tuner is moved off-channel then back. In this case, color, etc., will be best.

SPLIT PICTURE

The picture is split horizontally in this Sylvania 55k. In fact, I'm pretty sure that I have two complete pictures. There is a fast flicker as well. I've checked all of the resistors in the vertical circuits, and replaced the coupling capacitors. Any ideas?—C.T., Miami, Fla.

If your screen is full, but you have two pictures (with flickering), the vertical oscillator and output stages are working, but on the wrong frequency. Probably 30 Hz instead of 60 Hz.

This points to some trouble in the feedback loop between output plate and input grid. For a guess, I'd say the .01-µF capacitor from pin 2 of the 6EM7 to the 33,000 and 12,000-ohm resistors. If it shorts, it will upset the time-constants in the feedback loop.

(This used to be a very common complaint in one old set. We got to the point where we replaced a .0015-µF capacitor, and then looked to see if there was anything else!)

HUM-BARS IN THE COLOR

CTC-11, RCA. Shows horizontal bar about 3 inches high. This creeps up the screen slowly, then repeats. This symptom is present only on color, not in a black and white picture. A solution would be appreciated—F.M., Blaustalt, N.Y.

We can eliminate quite a few stages, right away. The dc power supply (this is a 60-Hz ripple, not 120 Hz) the video, and color-diff amplifiers (these work on B/W as well as color) and so on. This is caused by some stage which handles only color signals. It is most apt to be due to heater-cathode leakage in some tube which fits the spec's, and has a cathode bias resistor!

This would be: 1. The 6AU6 color bandpass amplifier; 2. The 6AL5 color phase detector; 3. The 6AW8 killer/1st video and 4. The G048 3.58 MHz osc and control. Try new tubes in these sockets, one at a time.

AGC AND AFC PULSE TROUBLES

I have replaced the flyback on a G-E SB chassis, with a factory part. Now I get a split picture, blanking bar in center. I can unhook the pulse coupling capacitor to the agc, and make the picture hold normally; horizontal hold very sharp, of course.

The waveform from the pulse winding to agc doesn’t look right. It’s more like a square wave than a sharp pulse. Could this be reversed?—W.M., Satellite Beach, Fla.

It is possible that the pulse is reversed, of course, and this would account for the problem. However, since this flyback fits into holes on the PC board, the pulse winding (terminals 1 and 2) would have had to be reversed accidentally at the factory.

Suggestion: take both the agc and afc pulse-coupling capacitors off, and check the amplitude and polarity of the pulse, right at the flyback. Terminal 1 should be ground, and there should be a sharp 250-V positive going pulse on 2.

LOW HV, NO FOCUS VOLTAGE

The high voltage is down to 12V. I have practically no focus voltage, but the cathode current of the 6JE6 reads 220 mA. This is on a Heathkit GR-295 color TV. I am getting some odd readings on the grid-drive to the 6JE6, too. 200 volts p-p at the oscillator plate, only 150 volts p-p at the 6JE6 grid. Also, when I pull the 6BR4, I lose all high voltage. —D.W., Vancouver, Wash.

You do have a lot of odd symptoms, and they all seem to point to one thing: You may have a small short in the high-voltage winding of the flyback. Check all of the other things first, of course; boost capacitor, yoke, and so on. However, the high cathode current of the 6JE6, with all outputs so low, points toward an overload of some kind. This can be due to the short in the high-voltage winding, which will make the 6JE6 draw too much current. (Field feedback from thoughtful reader confirmed this; bad flyback.)
ment heated up and went out in two days. Got another one like it, and it’s overheating. Cathode current of 6DQ6 is below normal. The only thing I can see is the resistance of the high-voltage winding; the spec-sheet, and the Sams Photofact data, calls for 550 ohms; I read 620 ohms.—C.G., Alamogordo, N.M.

While this is pretty rare, I am beginning to believe that your new (bleep) replacement flyback is defective. That high resistance reading on the high-voltage secondary could mean that it was wound with too small wire. If so, the PR loss would be excessive and the flyback would heat. I’d recommend replacing it with an Admiral replacement. Also, write to the (bleep) factory and let them know about this. Without field feedback, they can’t tell.

MUSICAL BARN

One of my customers has a Silvertone radio, which he plays in his barn. The 50H6X output tube burns out about every two months. In the shop, every-thing is normal; no shorts, etc. What could cause this?—R.B., Springfield, Ohio.

The first thing I’d check would be the ac line voltage in the barn. In some cases, rural lines run higher than they should, up to 135 volts in some cases. This would shorten the tube-life.

If this is it, you can add a small line-ballast resistor, to hold the voltage down to about 105 for best tube-life. Check this in the shop with a Variac, and be sure that the resistor is well-protected: it’ll get pretty hot.

OLD I.F. TRANSFORMER

I’m restoring an old Philco 39-45 radio. It’s got an odd 1st i.f. transformer, which is open. It has 5 leads instead of four. Can I get a replacement for this?—E.N., Princeton, Ill.

Not an exact replacement, but one that will work. This has a little tertiary winding, which is connected to the suppressor grid of the 78 i.f. amplifier tube. The diagram shows how, but not why. (Actually, I don’t know why. It may have been to neutralize a “hot” stage or to provide regeneration to “hop-up” the stage for more gain.)

Something like a J.W. Miller 512-C1 input i.f. transformer will work nicely. Just tie the suppressor grid of the 78 tube to its cathode, tune the i.f. transformer to 470 kHz (it is a 455-kHz type, but will easily tune to 470 kHz) and away you go.

PIECRUST FIX

(Note: This is the end result of a series of letters back and forth from here to the reader. Actually, he finally found it, himself. These are the best kind.)

The problem in this Zenith 16D25 TV was a tendency to piecrust or cog-wheel, mostly at low brightness levels. After checking out the anti-hunt net-work, and several other things in and around the horizontal oscillator, we found that for some odd reason, the set would piecrust when the load on the flyback (i.e., beam current of picture tube) was lowest.

The “fix” turned out to be odd, but simple. The value of the boost capacitor, originally 0.1 µF, was raised to 0.47 µF. This raised the boost voltage slightly, but stopped the piecrust completely!

Thanks to Ray Musick, Ballwin, Mo., for this oddball.

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Monitor has a solid-state high-voltage rectifier. The thing runs hot, and there is no high voltage. I replaced it with a German TV-65, and this ran for about one minute and broke down; it also got hot. What's going on here?—L.G., Chicago, Ill.

Disconnect the ultraviolet lead, replace the high-voltage rectifier again and see what you get on a no-load test. As you can see from the schematic, the high-voltage supply should deliver 11 kV at a 100-µA beam current. The RCA SK-3067 is rated at 11 kV, but I'd rather use an SK-3108, which is rated at 25 kV, 20 kV conservative, same current rating.

Also check all of the dc voltages on the picture tube. You have two possibilities here: first look for excessive positive bias on the grid, causing heavy beam current; second you could have a shorted picture tube. I used to say there was no such thing as a high-voltage short, but I ran into one.

**QUICK LIE DETECTOR**

Someone told me that there is a very simple circuit for a lie detector. Do you know what he meant?—J.H. Sandusky, Husky, Ohio.

There is. Just set the ohmmeter of your vtm or voltmeter to about the Rx1 Meg range, and hold the prods. You can make up "electrodes" with a larger surface area if you want to. When the person under test tells a lie, he'll either grip the prods tighter or start to perspire just a little. In either case, the ohms reading will go down. The lower his resistance, the bigger the lie, I guess. Sounds odd, but it works.

**LOW BRIGHTNESS**

This Magnavox 1924 has a very low brightness. The picture tube checks out OK, and the high voltage is good. I changed the video amplifier tubes; no help. Contrast control works. What is this?—F.L., Brooklyn, N.Y.

The most likely cause is picture tube bias. Check the voltages between grids and cathodes; this actually what determines beam current. If the grids are too far negative or cathodes too far positive (same thing), you won't be able to get enough beam current. Check the screens of the picture tube, too, just for luck.

**BLOBS OF COLOR**

I'm working over a G-E KD chassis. It has a peculiar problem. The screen of the picture tube is covered with odd blobs of color, fixed. I've degaussed it with an external coil, run the purity adjustments several times, and tried everything else I can think of. I ran the greyscale setup two or three times.

Nothing that I do has any effect on the blobs! I can see colors, when I put a picture on it, but I can't get the screen pure. What in the world is this?—I.L., Philadelphia, Pa.

I hate to say this, but if you can not make any difference in the blobs with a degaussing coil and the purity adjustments won't change them either, this is very apt to be something wrong in the picture tube; a distorted mask, etc.

For a definite check, try the chassis on a test-jig. If this effect disappears, that's it. New tube.

**NO FILAMENT VOLTAGE**

After replacing flyback on this Zenith 21J20, (with Zenith part) I can't get the 1B3 tube to light up. I don't get it; this is such a simple circuit.—M.S., Ashburnham, Mass.

It's probably too simple! You could have a couple of things causing this. Disconnect one side of the filament loop winding, and check for continuity across the filament pins, 2 and 7. Check that little 2.2-ohm resistor.

Also make sure that the filament...
is not shorted by one of the connections inside the tube. This can happen if other socket terminals are used to hold wires, etc. For a check, tack wires to a No. 222 penlight bulb, and tack this across 2 and 7. It should light, dimly.

INTERMITTENT ROLL
I'm working over an old Zenith 14N28 chassis. Got everything except an intermittent vertical roll. Checked all capacitors and resistors in the vertical oscillator, changed tubes. Any ideas?—W.M., Lagrangeville, N.Y.

Check the two integrators in this circuit; these are the little "three-legged" types, looking like dual ceramic capacitors. I doubt if they'll be shorted, but you may find the one in the feedback loop has increased in resistance, or is intermittently opening up. Normal resistance should be about 87,000 ohms for the one in the sync, and 90,000 ohms for the feedback-loop integrator. If you can't get the Zenith parts, a Centralab PC-407 or PC-408 will replace them.

BIAS DIODE REVERSED
I cleared up some other problems in this Westinghouse V-2486-2 chassis, and I've got one left. This is a bad fold-over from the bottom, in the vertical sweep. The bias on the output stage isn't right. Should be -15V and the best I can get is about -5V. I've checked the parts in the bias network, and I get +15V on the electrolytic capacitor.—G.M., Greensboro, NC.

You shouldn't. This voltage should be 15 volts negative; see diagram. All of the other parts seem to be of the right value, but recheck that bias rectifier diode; it must be reversed. Some of these little diodes are very hard to identify, but if you're getting a positive voltage out of it, it has to be in backward.

This would cut down the negative bias on the grid of the 17J28 output section, and cause the foldover.

BIAS DIODE REVERSED

![Diagram of 17J28 Vertical Circuit](attachment:image)

FALSE TRIGGERING OF BURGLAR ALARM

I've built one of the burglar alarm circuits you published in the June 1971 issue. Works fine, but it will "false-trigger". Finally found that turning on the fluorescent lamp in the kitchen caused this What can I do to stop this?—W.S., Buffalo, N.Y.

It sounds as if your alarm wiring is picking up some of the "rfi" or radio-frequency hash generated by some older fluorescent lamps. They can cause quite a lot, if unfiltered.

Two "possibles": One, shield the alarm wiring where it runs near the lamp wiring. Two, add rfi filters to the lamp circuit. Start with a couple of small bypass capacitors across the line, as in a in the illustration. If this doesn't get rid of it, add a couple of small rf chokes as in diagram b. This ought to do it.

R-E

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new literature

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free. Use the Reader Service Card inside the back cover.

ELECTRONIC PARTS catalog No. 8 is a 55-page book that contains various components and devices such as: computer keyboards, semiconductor coolers, heat sinks, transistors, Zener diodes, power transistors, IC's, diode rectifiers. SCR's, semiconductors, transformers, AM/FM stereo multiplex receiver, radionoise equipment, relays, printed circuit boards, computer-grade capacitors, potentiometers, power resistors, precision resistors, power supplies, switches, computer boards, speakers and damaged merchandise.—Delta Electronics Company, P.O. Box 1, Lynn, Mass. 01903.

Circle 42 on reader service card

QUIK-WRAP, catalog No. 350 presents hand-operated wire-wrapping tools, bare ground stripping tools, hand unwrapping tools, wrapping tool kit, unwrapping tool kit, manual wire unwrapping tools, and manual wire wrap gun & accessories. Includes descriptions and pictures of each device.—Jonard Industries Corp., 3047 Tibbett Avenue, Bronx, N.Y.

Circle 43 on reader service card

CB RADIO REPAIR COURSE, 8-page booklet tells about 70 information-packed programmed lessons—25 on basic principles, 25 on actual CB circuits and 20 about CB servicing.—CB Radio Repair Course Inc., 15 South Overmyer Drive, Oklahoma City, Okla. 73127.

Circle 44 on reader service card

ALARMS CATALOG includes ultrasonic-sentry and electro-sentry burglar alarms and magnetic sentry burglar and fire alarm descriptions as well as alarm accessories and a variety of sensors and other hardware.—Audiotex, GC Electronics, 400 South Wyman Street, Rockford, Ill. 61101.

Circle 45 on reader service card

Write direct to the manufacturers for information on items listed below:

1973 MASTER INDEX is a 1957-73 listing for service data of about 40 manufacturers of TV receivers by chassis number. Radio listings are also presented in same fashion. Contains component stereo equipment too.—RCC Publications, 461 King Street West, Toronto, Canada MSV 1K8.

1973 SEMICONDUCTOR CROSS-REFERENCE GUIDE HMA-07. Approximately 43,000 semiconductor devices are cross-referenced to ATV replacements. Included are 1N, 2N, 3N, JEDEC, manufacturers' regular and special house numbers and many international devices with emphasis on Japanese types. 472 HEP items are listed. All Motorola HEP devices are listed by type numbers and case style with a packaging index, device dimension drawings and selection guide information.—Motorola HEP Semiconductors, P.O. Box 2953, Phoenix, Ariz. 85036.

SOUND SYSTEMS. 15-page booklet outlines sound reinforcement concept and functions of system components. Path of signal is traced from the source through components in systems that range from elementary to complex.

System organization is depicted by flow diagrams with line drawings of actual components. Two tables assist in selecting appropriate volume controls and determining correct power requirements; check list aids in furnishing data necessary for construction of sound system.—Dukane Corp., 200 Dukane Drive, St. Charles, Ill. 60174.

Motorola HEP Semiconductors, P.O. Box 2953, Phoenix, Ariz. 85036.

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Motorola HEP Semiconductors, P.O. Box 2953, Phoenix, Ariz. 85036.
REPAIRING CALCULATORS
(continued from page 36)

unit is located, a messy procedure if the readouts are soldered in place. If a segment fails to light in only one readout, by the way, either the device or the solder joints at one or more of its pins are defective.

Automatic clear
When initially turned on, most calculators automatically reset to zero without the need for a command from the CLEAR key. A typical automatic clear circuit is shown in Fig. 8. In operation, the circuit grounds the clear line momentarily after power is applied to the machine. If the capacitor or resistor shorts, the indication is no display and no entries are possible. A shorted diode won't affect the circuit each time the power is activated, but occasionally the machine will not automatically clear. An open capacitor or diode will disable the circuit, but the machine can be manually reset via the CLEAR key.

Sign and error
The first readout on a display is generally used as a status indicator and receives only a few commands. The minus sign indication and overflow signal come directly from an LSI chip through buffer stages. As shown in Fig. 9, there are four active components involved with these functions.

Circuit boards and soldering
Super small calculators frequently require double-sided printed circuit boards with plated-through holes. When a component is being removed from a plated-through hole careful desoldering procedures must be followed. Too much heat can cause the metal land to become detached while insufficient heat can result in the plating coming out with the component's lead. Experience is the only way to determine the amount of heat required for the component and the size of the land around the lead hole.

When removing a component, always cut the component leads and then remove one lead at a time. Once the leads are removed it's a simple task to remove any remaining solder with a solder puller. Component replacement is a simple matter, but be sure the replacement part is at least equivalent in value and tolerance.

On tightly packed boards be careful to avoid solder bridges. To reduce this possibility use a small wattage soldering pencil iron and 24-gage or smaller solder. Heat sinks are usually not necessary if solder time is limited to a few seconds and if you apply solder just after heat is applied. Metal lands that run very close together along the board are particularly susceptible to shorts caused by small slivers of metal.

MOS LSI handling precautions
So long as they are in the circuit, MOS (Metal Oxide Silicon) LSI (Large Scale Integration) IC's are practically trouble-free. When the chips are improperly handled, however, they become susceptible to damage from static electricity and mechanical pressure.

When removing a chip from a socket ground the fingers on the calculator ground line (making sure the
other socket receptacles.

When installing a chip in a socket, ground yourself and then carefully line up all the pins with the socket receptacles. Apply gentle pressure at first one end and then the other until the IC is secure in the socket. CAUTION: If the MOS LSI IC's are soldered in place DO NOT attempt removal unless the proper equipment and experience is available.

Troubleshooting the LSI portion of a calculator is extremely difficult if a block diagram showing inputs and outputs for each chip is not available. If the diagram is available, it can be used to work from the output chip or section of a chip backward to the input of the preceding chip. The procedure is more difficult in multi-chip calculators since some chips invariably receive feedback input information from other chips.

Case history

The MITS 1440 is a multi-function desk calculator with a square and square root capability. The machine can also store a 14 digit word in memory. The unit uses fourteen readouts in its display and six LSI chips. A machine came in for service in which the overflow indicator worked but the display failed to operate. The power supply voltages and the pulses on the digit lines and BCD lines from the output chip to the display buffer were all good. From here on let's quote from the servicing technician's report:

"Having no other place to go I began looking at the input and output signals around the output pin. I started at the outputs of the circuit (pins 4 and 10 of IC11), found they were not present, and began working backwards until finding correct input pulses at pins 8 and 9 of gate 3-a. There was no output at pin 10 of the IC socket. I then checked pin 10 at the IC lead and determined that it was operating properly. A continuity check showed an open between pin 10 of the socket and the IC. Resoldering the pin failed to correct the problem. I removed the socket and found that pin 10 had been broken internally. The socket was replaced and when the chip was reinstalled the machine operated properly."

There are numerous examples of this kind of troubleshooting procedure. The best way to learn the technique is to service some actual calculators.

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The FM-2400CH provides an accurate frequency standard for testing and adjustment of mobile transmitters and receivers at predetermined frequencies.

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5 SOLID-TUBES replace 25 vacuum tubes

Pull out those troublesome vacuum tubes. Plug in the new SOLID-TUBES from EDI, pioneers in high voltage, solid-state devices for the TV industry.

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>REPLACE VACUUM TUBE TYPES</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-3A3</td>
<td>3A3, 3A3W, 3B2, 3CA3, 3CN3, 3CJ3, 3CZ3, 2CN3, 1B3, 1G3, 1K3, 1J3</td>
</tr>
<tr>
<td>R-3AT2</td>
<td>3AT2, 3AW2, 3BL2, 3BM2, 3BN2</td>
</tr>
<tr>
<td>R-3DB3</td>
<td>3DB3, 3DJ3</td>
</tr>
<tr>
<td>R-2AV2</td>
<td>2AV2, IV2</td>
</tr>
<tr>
<td>R-DW4</td>
<td>6DW4, 6CK3, 6CL3, 6BA3</td>
</tr>
</tbody>
</table>

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There's so much new test equipment, I'm getting in shape to carry my tool kit.

Accidents are the invasion of the unprepared by the unexpected. But if intrinsic safety is considered in the basic design of electronic equipment, you will not be unprepared and no sacrifice of performance or convenience or any significant cost penalty need arise. In this book, the author sets out to present background information, past experience and present-day practice in making electronic equipment safe in explosive atmospheres and where flammable fluids are used.


A step-by-step guide to all types of basic electronic measurements using simple, inexpensive test equipment. In this book, the mysteries usually associated with many electronics tests are unveiled. The author shows how to get accurate, meaningful measurements with ordinary vom's, oscilloscopes, etc. by taking into consideration the errors inherent in most test equipment. The important thing is knowing and understanding the true nature of what is to be measured.

EASI-GUIDE TO BOAT RADIO by Forrest H. Bell. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 160 pp. $3.50.

Here is an introduction to boating radio. Photographs show what you can do with a radio in your own boat, how to find it, select one, the steps in installing it and how to use it. One chapter covers FCC rules that apply to the pleasure boater. The reader sees how to take care of his boat radio and learns what to do if it breaks down.


Consists of a set of tests and study material based on those suggested by the FCC in their study guide and intended to provide an additional means of preparing for the federal tests. The test assumes that the reader already holds a third class radio/telephone license. The first section of the book is a self-study ability test which enables the student to determine which areas he requires the most practice in. Then each additional section presents a series of questions and answers similar to those in the actual FCC test and should enable the candidate to get an actual picture of what to expect when he takes his license examination.


A completely up-to-date approach that provides sound coverage of solid-state color television receivers, circuitry, operation and troubleshooting. Carefully illustrated with line drawings and photographs, some in full color, this book accentuates system operation and color television transmission. Analyzing basic color fundamentals, the author surveys color television technology today. He covers all types of operations from systems, color picture tube principles to rf and if. circuitry. The author explains troubleshooting based on picture analysis and instrument troubleshooting.


A manual of practical transistor circuit design, this book gives techni- cians, junior designers and engineers an understanding of meaningful design relations requiring a minimum of mathematical analysis. The text covers vital subjects such as single-stage and multi-stage amplifiers, class A and class B power amplifiers, audio, video, uhf and microwave circuits, FET and MOSFET amplifiers and linear integrated circuits.

HOW TO BUILD SIMPLE ELECTRICAL METERS & INDICATORS by Charles Green. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 128 pp. $3.95.

For students who wish to learn the fundamentals of electrical instrumen- tation and who understand basic electrical theory. Each chapter covers a particular milestone in the history of electricity, discussing the scientists and inventors involved. The basic theory and construction details of meter and indicator projects that are related to a particular part of electrical history are included in each chapter. The projects start simple and become increasingly more complex. Dry type is kept to a minimum. Standard electrical components are used. Projects include an electroscope, a saltwater voltmeter, a hot-cathode neon bulb tester, an electrically heated and superheated gasometer, a polarized light meter, a galvanometer, a reputation moving iron meter, a moving coil meter and experiments with a moving coil meter.

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VARIABLE BATTERY ELIMINATOR

We do industrial work, including metal locators and pipe finders. Occasionally an older type using ½-volt tubes crops up. You will find a Geiger counter, timer, photo cell and other old devices still in operation. But enough of this work does not come in to keep several batteries in stock, so we designed a variable "B" supply. In our case, we found some old preamplifiers using a 6X4 rectifier and 6AU6 and 6C4 amplifiers. We used these for basic units. The power out is 0 - 150 volts at 40 mA (it depends on power transformer you use). We used silicon rectifiers.

The choke can be any 200-500 ohm. 40 mA unit or even a 6V6 (or similar) audio output transformer with voice coil leads clipped off. The tube can be almost any audio output type, 6V6, 6F6, 6L6, 12L6 etc.

The meter can be any voltmeter reading up to 150 volts or more or any instrument from 1.0 to 10 mA with R1 serving as a multiplier resistor. The value of R1 is determined by dividing 1.0 volt by the meter's full-scale current in amperes and then multiplying the resultant (sensitivity in ohms per volt) by the maximum voltage you want to read. For example, suppose you come up with an old 0 - 5 mA meter and want it to indicate 150 volts full-scale. The value of R1 is then

\[ 150 \times \frac{1}{0.005} = 150 \div 0.005 = 30,000 \text{ ohms} \]

Similarly, R2 would be 150,000 ohms with a 1-mA meter movement. (We have disregarded meter resistance in this case, but if you want to get an exact value for R1, subtract the meter resistance from the calculated value.)

To use: Connect the A (flashlight or other battery) to the filament circuits and connect this B supply in place of the 22½-, 45- or 67½-volt B battery and turn the control for zero voltage. Turn on unit under repair and turn on B supply. Then slowly turn pot until meter reads wanted voltage.—W. G. Eslick

MORE ON THE FUNCTION GENERATOR

The function generator on the cover and top of page 41 of the July issue includes a digital frequency counter readout to indicate its output frequency. Technical details and construction data on this feature were not included in the article but will be the subject of an article in an early issue.

We regret that this fact was not mentioned in the July article.
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RCA 110" FLYBACK TRANSFORMER

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Includes 110 large type pages for $9.00 exclusive of tax.

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"THIRD hand" test probes, reach into out of way places - Insulated - cannot slip - accommodates tape wire or banana plug - no soldering

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Circle 26 on reader service card

AUGUST 1973 • RADIO-ELECTRONICS
try this

**SEPARABLE POWER CORDS**

Equipment designed to operate from the power line naturally needs a line cord. Any time its not in actual use, however, the trailing cord can be just a plain nuisance. By modifying a few TV cheater cords you can eliminate the line cord, an indicator light, and on-off switch in each of your future projects. The interlock receptacle which replaces them serves as a solid tie point—something which would have to be provided in any case.

The blob on the cord (see photo) is actually an NE-2 neon lamp in series with a 100,000-ohm resistor across the power line. No break is made in the cord, the leads are forced between the insulation and wire through punctures made with an awl.

With the bulb and resistor snug against the cord, coat the whole section with a generous blob of “Devcon Five Minute Epoxy.” You’ll have to keep rotating the cord until the epoxy sets, since it tends to drip off. If you object to the “free form” appearance of the indicator, form a modeling clay mould around the line to retain the epoxy.

While you’re making up the cords you might want to add a line fuse and avoid repeatedly duplicating another item.—R. G. Cooper

**USEFUL SPRING HOOK**

A spring hook—an almost indispensable tool when repairing record players or tape recorders—can be made in a short time from a bicycle spoke. Cut a piece of spoke about eight inches long. Carefully file or grind about one inch on each end of the spoke to a fine point.

Heat each filed end with a propane torch or other gas flame and allow to cool. This facilitates bending to shape.
Bend a "S" shaped hook in one end and a "C" shaped hook in the other. Note that the first hook has a reverse bend in it (a in the drawing), which allows the tool to be used to push on a spring end where it is out of reach of other tools. After careful bending, again heat each end, in turn, to cherry red, and plunge into cold water to harden it.

Use the tool as shown in sketches. To push a spring into place, use the reverse-bent hook as in c. Push carefully, and let the loop of the spring drop into place. Then, remove the spring hook. A similar procedure is used for pulling a spring into place, as shown at d.—Hugh Gordon

DIP HANDLE
Handling IC packages with their delicate leads can present problems. Fingers obstruct the view when aligning the leads for insertion, and when the units are closely spaced removal frequently results in mangled leads.

Professional tools are available, but for occasional use the battery clip shown serves very well. The clips are available in various sizes from automotive stores and are used for battery charging. The "5 amp." size needs only a little work with a file to clip neatly under the ends of the DIP package.—R. G. Cooper

USING DULL WIRE STRIPPERS
If your automatic strippers get dull and won't strip properly, simply squeeze the end of the wire being stripped with a pair of long-nose pliers. The wire will strip cleanly.—A. E. Plavcan
FM STEREO DECODER
(continued from page 62)

another 19-kHz signal which is in phase with the pilot tone. This
in-phase signal is compared with the in-
coming 19-kHz signal in the stereo
switch demodulator and yields a dc
component proportional to the pilot
tone amplitude. This dc component is
filtered and applied to the trigger cir-
cuit which activates both the stereo
switch and an indicator lamp.

One of the advantages of a
phase-locked loop arrangement is the
fact that a fairly substantial variation in
free-running frequency can be toler-
ated without degrading the perfor-
ance in terms of stereo separation or
distortion. Once "locked", frequency is
absolutely constant (19 kHz) and,
more important, phase lag or lead
(compared with the incoming pilot tone) is also constant over a wide
range of free-running frequencies.
Motorola indicates that satisfactory
performance will be maintained over a
range of 2.5% detuning of free-tun-
ning oscillator frequency. This corre-
sponds to end frequencies of 19,475
Hz and 18,525 Hz—a far cry from the
30-Hz departure from 19-kHz associ-
ated with conventional transformer
and coil-tuned multiplex decoder cir-
cuits. If no regard is given to tempera-
ture compensation, free-running fre-
quency will vary with temperature in
accordance with the chart of Fig. 10.
Under these circumstances, the 2.5%
departure from 19 kHz will occur over
a wider range of temperatures than is
ever likely to be encountered in con-
sumer use of the tuner or receiver
product.

Although the phase-locked loop
principle has been known and under-
stood for more than 40 years, its prac-
tical use in consumer electronics had
to await the development of large-
scale integration of circuits into single
IC chips which we now take for
granted. The Motorola MC1310P con-
tains no less than 58 active transistor
elements and three diodes plus a Ze-
ner diode, not to mention scores of
built-in resistors.

The RCA CA-3090 contains 128
transistor elements, 14 conventional
diodes, 1 Zener diode and some 114
resistive elements. Both devices are
contained in a chip measuring approx-
imately ⅛ inch by ⅛ inch x 3/16 inch!

Other applications for phase-lock-
loop circuitry in high fidelity equip-
ment are being devised in laboratories
around the world. As more informa-
tion becomes available, we shall per-
haps devote a future article to other
hi-fi applications of the phase-lock-
loop circuit.
Build A TV Typewriter
Alphanumeric character generator connects to the antenna terminals of any TV set and produces a message of your choice on the screen. What will you do with it? To name just a few: it's a teaching machine, a computer terminal, a cable system announcement generator. It's written by Don Lancaster.

What Hi-Fi Speaker Ratings Mean
R-E's Contributing High-Fidelity Editor Len Feldman explodes the myths of speaker-system spec sheets and winds up with a sample of what a speaker spec sheet should look like.

How To Wire A House For TV
All about master antenna systems for the one-family home. What equipment to use, how to install it, what it does for you.

How To Select TV & FM Antennas
Forest Belt tells how to make that final decision and buy the antenna that's best for you.
RADAR OVEN REPAIRS
(continued from page 47)

two readings is the leakage level of the oven at that particular point.

Leakage measurements should be taken along all edges of the door, and
at the grille in the door, if the oven has a viewing window. In addition, leak-
age tests should be performed at all points on the oven case where leakage
could possibly occur—at the slot between the timer panel and the oven,
along the top and sides of the oven, and at the rear of the oven. Excessive
leakage at the rear or top and sides of the oven may indicate that the mag-
netron and rf gaskets are not seated properly.

INTERNATIONAL CRYSTAL makes this elec-
tronic oven. Two views show both the exterior
and interior of the quick-cooking machine.

Also check the oven door with
shims placed between the door and
the oven. The thickness of the shims
should be such that the oven door in-
terlock switch is just barely defeated.
If leakage on this test is excessive, the
interlock switch should be adjusted so
the oven will not turn on unless the
door is adequately sealed.

If you find excessive leakage
around the door, clean all surfaces
and seals with a damp rag and a mild
detergent. If microwave leakage is still
excessive, the Teflon or metal seals
may have to be changed.

Because he has the test equip-
ment and electronic skills needed to
repair microwave ovens, this venture
can be a profitable undertaking for
the electronic service technician. But
he must be aware of the potential
hazards to himself when working on
this type of equipment, and also of his
responsibility to his customer to limit
radiation leakage.

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23 Channels and "Mars"
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Marine-Monitor

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Los Angeles, California 90018

Circle 69 on reader service card
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**LOGIC NEWSLETTER**, design and construction, sample copy $1.00. LOGIC NEWSLETTER, Box 250, Waldwick, N.J. 07463

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side down. The obstruction can be pushed out with a thin rod.

The pipes leading to the brush compartment can be clogged by anything that gets in. These can be cleaned out by running a wire through them.

Electrical troubles are standard. The most common one is probably breakage of the line cord, from continued pulling and flexing. Since these machines are used on damp floors, make a careful inspection of the line cord at regular intervals. If you see any cracks or breaks in the jacketing or insulation, replace the whole cord. Don’t take chances.

The on-off switch is usually a slide or toggle type, mounted on the top of the handle. They do wear out from continual use. Replace with identical types, since they usually fit into slots in the handle. Most of them are made on small plate, held to the handle by screws.

Mechanical troubles are “stock”. If the machine has a gear box, it will be filled with a fairly heavy cream lubricant. If you find traces of grease on the floor or on the brushes, take it apart. You’ll probably find that some of the screws holding the cover plates on the gearboxes have loosened from the vibration, and dropped out, allowing the grease to leak. In some cases, you’ll have to take the cover plate off, clean the edges and replace the gasket. If you happen to have a tube of Soft Permatex in your garage, it will often make very good gaskets for these little boxes.
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Dear Radio-Electronics Readers,

The first thing I would like to do this month is to thank those of you who have taken the time to write and comment on this series of ads. I am glad to hear that you are enjoying them and I will do all I can to keep them as interesting and informative as possible.

This month I want to tell you about a new "now it can be told" kit that we are offering. This is our new FG-2 function generator. It is a considerably improved version of the instrument described in last September's Radio-Electronics. Since the original instrument was designed, even better waveform generators have become available; so it was "back to the drawing board". The original instrument was quite good and a real bargain at our price, but we don't like selling kits that we know can be considerably improved upon. Anyway, all of you who placed orders for the kit after the first of the year had to wait while we got the new FG-2 ready. Now that we have enough stock to ship these without a long delay we want all of you to know about it.

In the FG-2 the basic waveform is a triangular wave, just as in the original circuit, but in the new instrument this waveform is generated by two current sources, and a pair of comparators that are connected to an external capacitor. The current source produces a very linear ramp whose amplitude is controlled by the trip point of the first comparator. The second current source works in the opposite direction and gives us a downward ramp that is terminated by the second comparator, and the process is then repeated for the next cycle of the waveform. This system gives the waveform a very constant amplitude which cannot change with frequency. The triangular waveform is then fed into a sixteen breakpoint shaping network (yes I said 16). This, in combination with the stable amplitude, produces a sine wave with less than 1.0% distortion at any frequency. The comparators are also used to trigger a flip-flop that produces a square wave. To get pulse and ramp waveforms, all you have to do is make the charge and discharge currents unequal. The output of the generator is fed into a high speed op-amp used as a buffer. This gives us a low output impedance and isolates the generator from any loading effects. The circuit is DC coupled throughout and a switch allows you to select the waveform offset. You can put the center, the top, or the bottom of the waveform on DC ground and it stays right there no matter what the level setting. This makes the FG-2 super handy for checking logic circuit toggle levels and stuff like this. There is also an AC position for use when the circuit point has voltage present on it.

So for only $39.95 you can get this elegant little instrument. This is less than you would normally pay for a Sine-Squarewave generator with the same frequency range. Think about it--five different waveforms from 0.1 Hz to 100 KHz. Now isn't that enough reason to try a kit from the "other" kit company.

If you are looking for an interesting hobby and don't read schematics, or color codes please look elsewhere. If you are really serious about electronics, or work in the field, we would like very much to have you try one of our kits. We know you will be able to appreciate the quality of our parts, our engineering and the bargain our price represents. For instant shipment, call us and use your Mastercharge, or Bankamericard. For more details on our kits circle on the reader service "bingo" card and I will get a copy of our latest catalog to you as quickly as possible.

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