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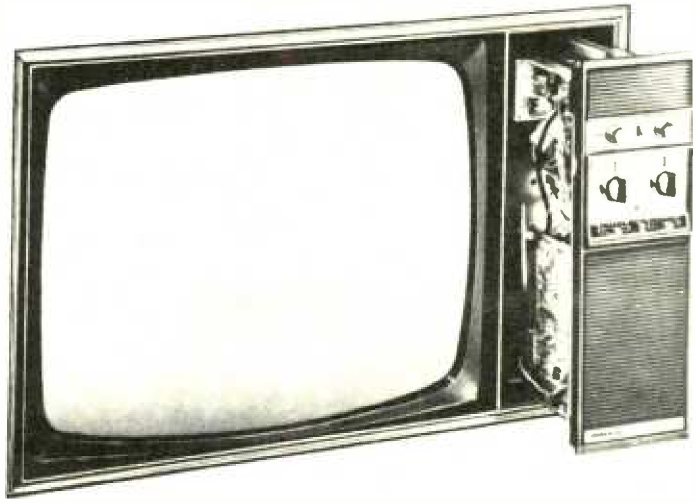

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AU7500


AU6500

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Among the many exciting features of the AU9500 are a wide variety of conveniences, such as a 4-channel adaptor switch, for QS, SQ, or CD-4 add-on units, the ability to handle up to four tape decks, and provision for tape-to-tape dubbing. Triple tone controls allow even the fussiest listener to adjust the AU9500's response to his taste.

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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Circle 2 on reader service card

Radio-Electronics

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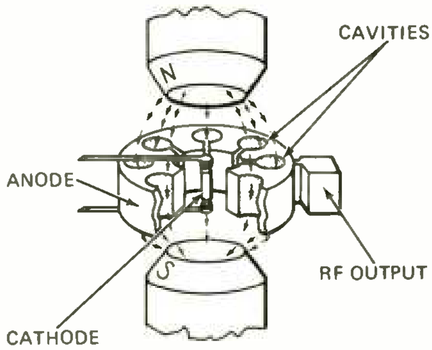
More than 65 years of electronics publishing

AUGUST 1973

ON THE COVER

A LOOK INSIDE the new Heathkit model IC-2009 electronic calculator you can service yourself. It has 8-digit display, constant key, floating decimal and features plug-in keyboard and display panel for easy serviceability.



FUNCTIONAL DRAWING OF A MAGNETRON—the heart of the microwave oven. Are you up on latest servicing tricks?

. . . . turn to page 37

Cover photograph by Walter Herstatt
Cover design by Louis E. Rubsamen

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looking ahead

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 each revolution. For reverse, it goes back to the preceding track. These instructions can be fed to the scanning mirror through controls on the record-playing 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 to 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 in-line electron gun.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

new & timely

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 of 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.

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 vhf signal, which sounds an alarm and actuates a printout at the fire station. The box transmits in the 72-76-MHz region between TV channels 4 and 5. It also has pushbuttons for police, medical aid and road service calls.

Bronx electronic technicians organize new association

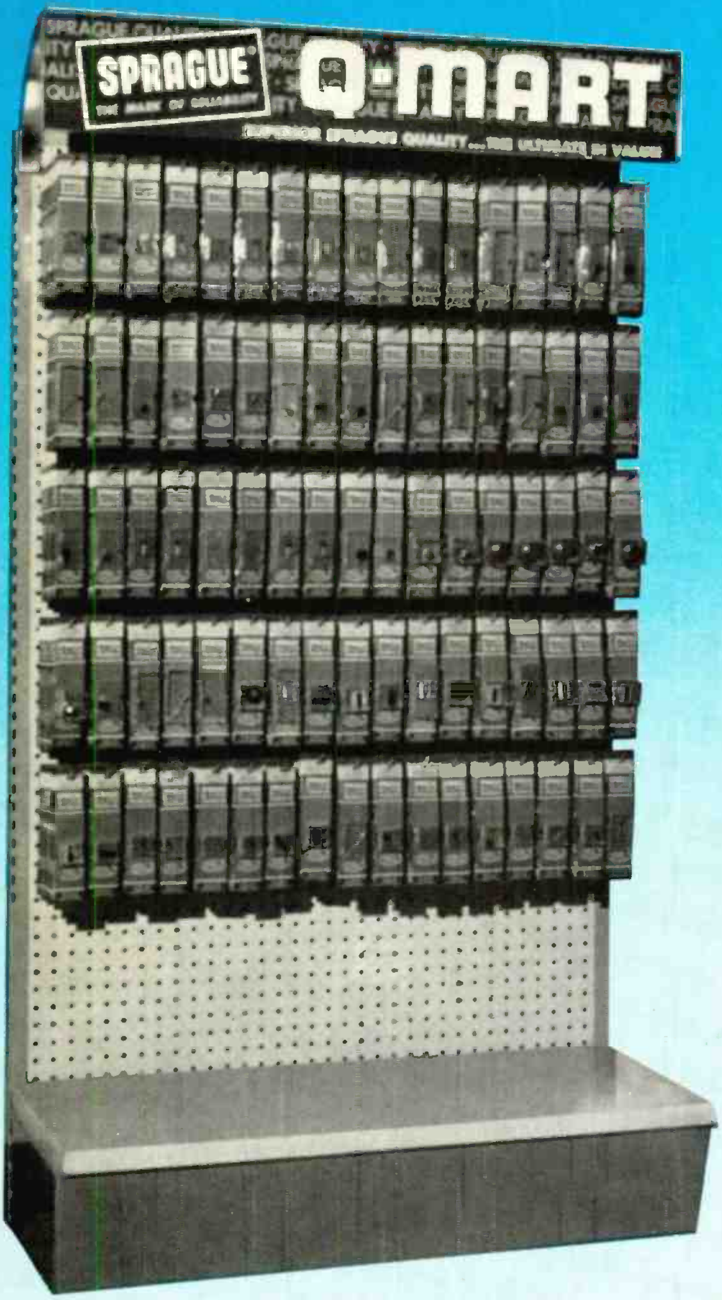
A group of electronic technicians and shop owners of the Bronx, NY, met recently to discuss the formation of a new local association in their area. They invited two members of the Television Service Association (TSA) of Northeastern New York, a group headquartered in Albany, to answer questions. The 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.

SEATED, LEFT TO RIGHT: John Matos, Sylvania instructor; Miguel Rosado, Astro Electronics; Morris Rosenthal, David Goldknopf, Kingsbridge TV; Andy Hegh, Andy's TV; and Robert O'Casio, Telefix, Inc. All the shops are in the Bronx. STANDING: Robert Plunz, TSA, Inc., Albany, N.Y.; Sarah O'Casio, Telefix, Inc. Warren Baker, of TSA, Albany, N.Y., was operating the camera.

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.

(continued on page 12)



New

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NRI Kits and Equipment

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 (continued from page 6)

Snooper detects hidden fire

A recently patented piece of fire-fighting 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."

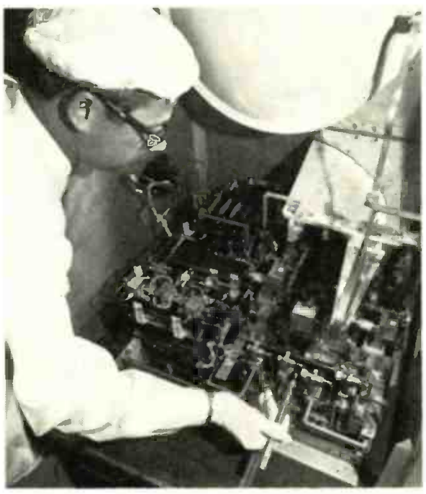
Since television broadcasting takes up the area between 174 and 216 MHz, and 470 to 890 MHz, the feeling that the government is looking at part of the spectrum allotted to TV broadcasting is strong, especially as other frequencies in the region carry important services that the government would not be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

The request has puzzled some in the FCC, because the government recently returned to the FCC for reallotment 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 orbited 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.

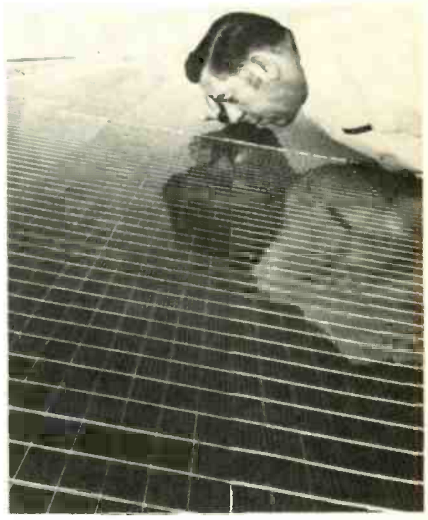


MILLIMETER WAVE COMMUNICATIONS equipment, to orbit the earth aboard the ATS-F satellite, may open up needed "talking space" in the presently unexploited 20 to 30 GHz spectrum.

The Millimeter Wave Experiment contains two transmitters, which will radiate CW (continuous wave) and multitone signals on 20 and 30 GHz. (1.5 and 1 centimeter, or 150 and 100 millimeters). These will be received by the Goddard earth station near Rosman, N.C.

Two experiments will be performed. In the first, signals will be transmitted from the satellite to earth, to check atmospheric effects on the signal quality. In the second experiment, signals will be sent from the earth to the satellite on present earth-satellite communications frequencies and retransmitted to earth in the millimeter wave bands.

It is known that heavy rainfall and—to a lesser extent—other forms of precipitation, varying temperatures and possibly other factors have an effect on signals at super-high frequencies. These tests are intended to find out just how much these factors could affect a practical communications system.



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 Scheibly, make the 10-foot-high NASA Nimbus-5 look like a butterfly. As a contrast to the wide-spreading 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

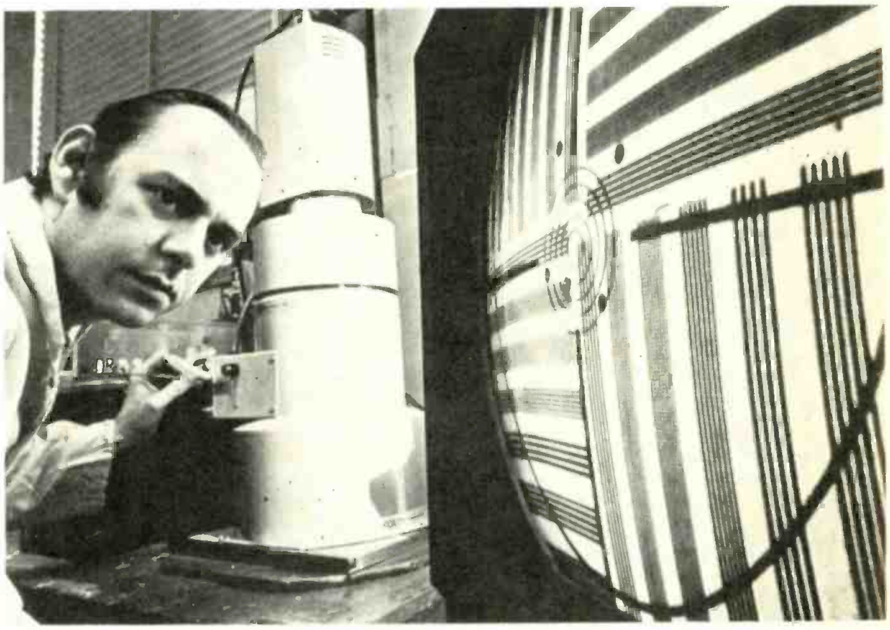
A new system of teaching the basic principles and theories of electronics by correspondence, using pre-recorded cassette tapes, has been announced by RCA Institutes' director L. W. Snow. Studying with pre-recorded tapes is, according to Snow, the nearest thing to having an instructor guide the student through each lesson. The "instructor"

(continued on page 14)

new & timely

(continued from page 12)

explains the material as the student reads the text and describes the schematic illustrations in easily understood terms. **R-E**



TELEVISED X-RAY MAGNIFIES IMAGES 6,000 times, bringing up details that would be unnoticeable otherwise, and reducing exposure to patient, technician and radiologist. The new system is called "Dynavision" and was developed at Raytheon's Machlett Labs, in Stamford, Conn.

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letters

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.)

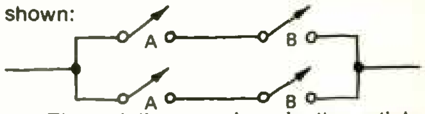
I saw him do this in 1925 and he had been doing this for some 30 or 40 years before then.

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:



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 so!)
The Idempotent Law states: $B + B =$ B NOT 1.
4—We should now continue:
$A(B + B) = Y$
$A(B) = Y$
A and $B = Y$

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

GEORGE J. BEAUPRE
Danvers, Mass.

R-E

How to become a "Non-Degree Engineer"

Exciting careers in the new industries of the Seventies are waiting for men with up-to-date electronics training. Thousands of engineering jobs are being filled by men without engineering degrees—provided they are thoroughly trained in basic electronic theory and modern application. The pay is good, the future is bright...and the training can now be acquired at home—in your spare time.

ELECTRONICS, The Science of the Seventies, has created a new breed of professional man—the "non-degree engineer." Because industries depend on them to meet emergencies, move in and keep things running, they get top pay—and a title to match. At Xerox they're called Technical Representatives. At IBM they're Customer Engineers. In radio and TV, they're the Broadcast Engineers.

But these men must know more than how to solder a connection, or test circuits or replace components. They need to know the fundamentals of Electronics and how to apply them.

How can you pick up this necessary knowledge? Many of today's non-degree engineers earned their electronics diplomas at home from Cleveland Institute of Electronics.

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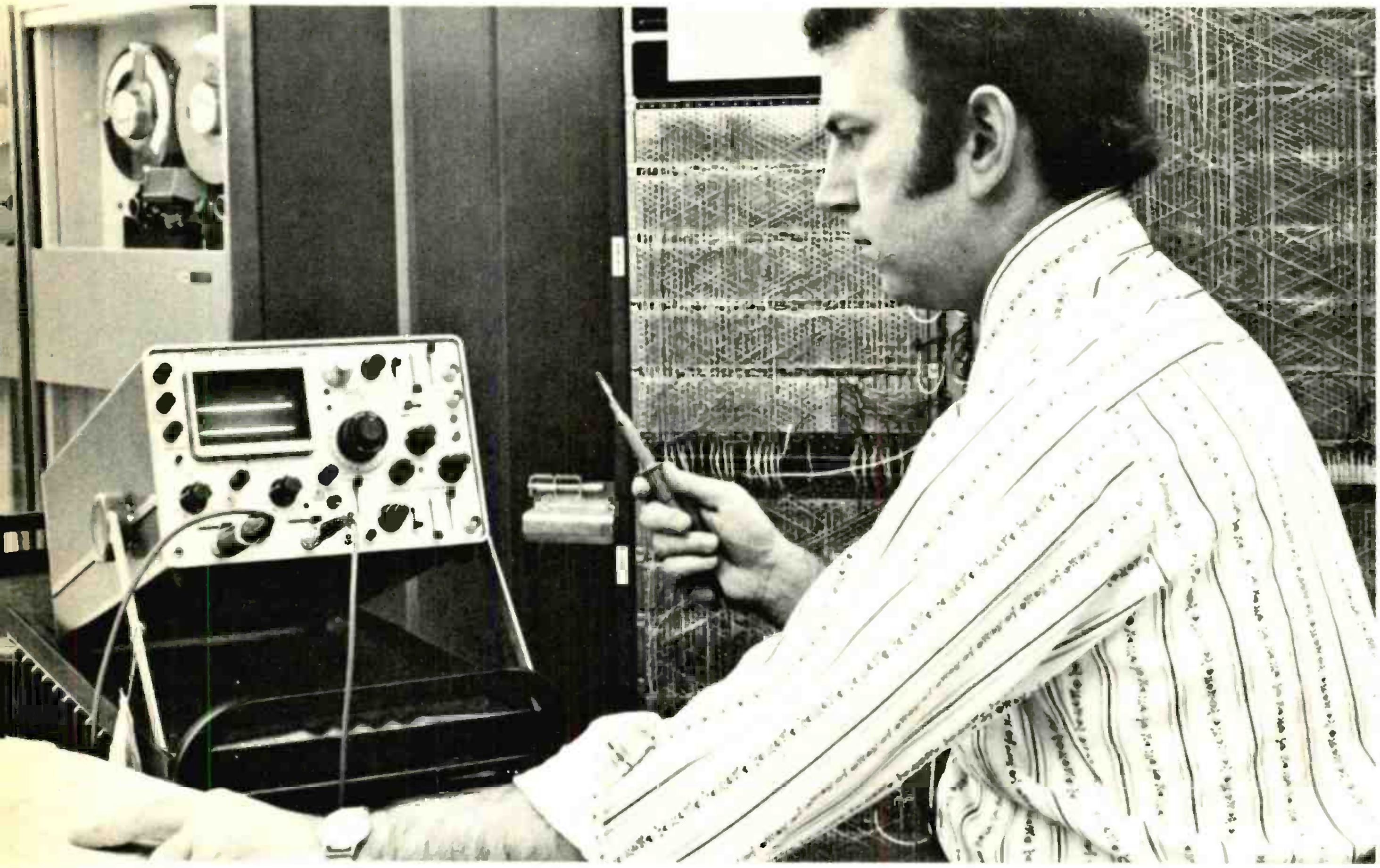
CIE is the largest home-study school in the U. S. specializing exclusively in Electronics. The seven CIE career courses provide solid preparation for nearly every career field in Electronics today.

The Electronics Technology with Laboratory Course teaches you fundamentals. With a 161-piece space-age laboratory, you apply the principles you learn by analyzing and troubleshooting electronics equipment.

If an FCC License is your goal, five of our courses prepare you to take the Government FCC License exam. For the man already working in Electronics, CIE offers a college-level Electronics Engineering Course.



appliance clinic

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, so that the brush revolves, and actually moves back and forth at the same time. This leaves a track of small circles on the floor.

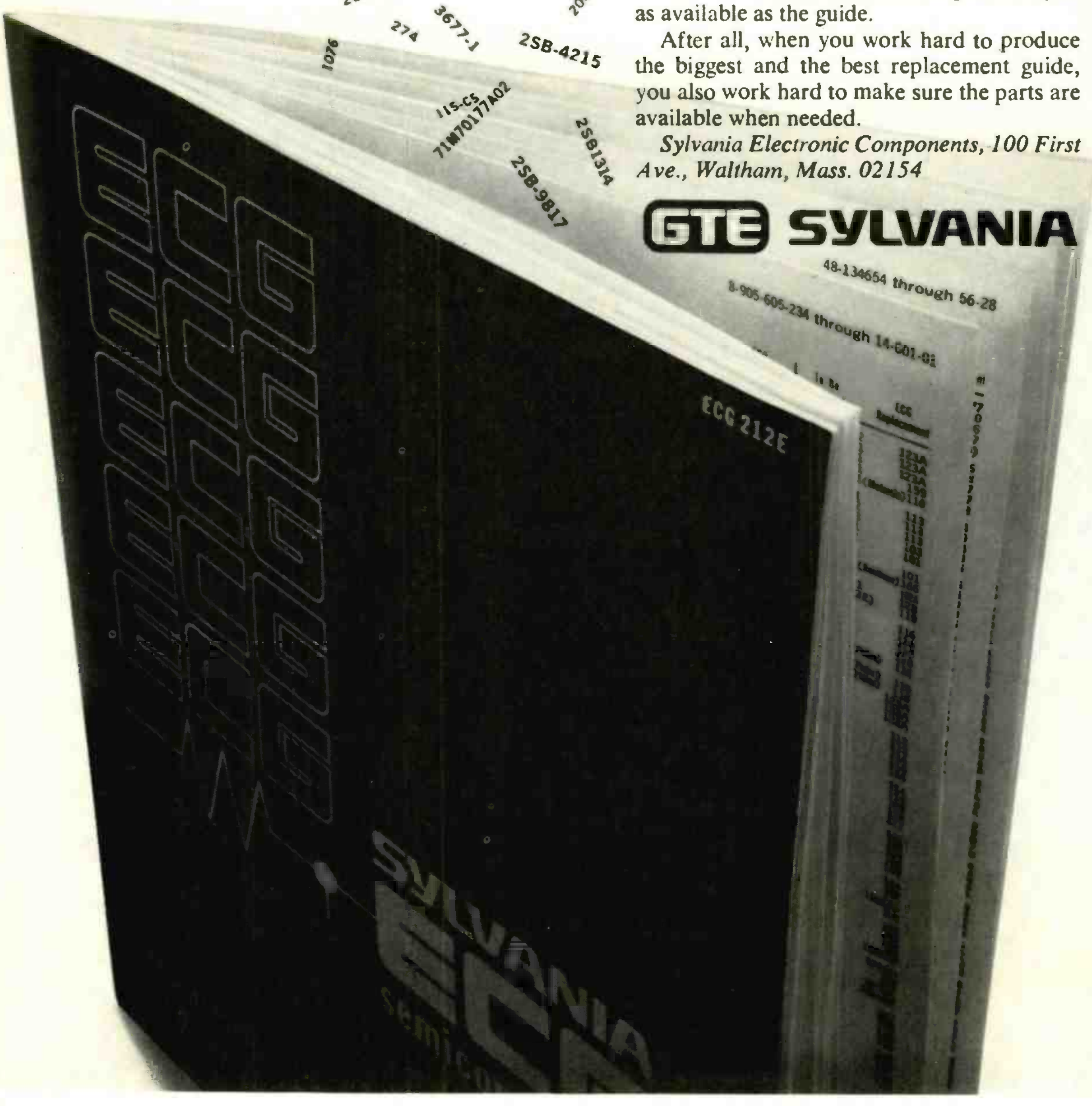
In the two-brush machines, the brushes are usually built so that they rotate in opposite directions. This keeps the machine from wanting to "skate" to one side when it's running. This also leads to some novel designs and features. In one popular model, the motor has a shaft coming out of each end, with 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 counterclock. 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 counterclock 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)



ECG 212E
48-134654 through 56-28
8-905-605-234 through 14-001-03

Our new receiver can demodulate or decode any kind of 4-channel including some that haven't been invented yet.

equipment report

Heathkit GR-110 VHF Scanning Monitor

Circle 100 on reader service card

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 abandoningly frustrating in comparison to the auto-scan technique. The Heathkit 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 rescan 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 straight-forwardness 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. **R-E**

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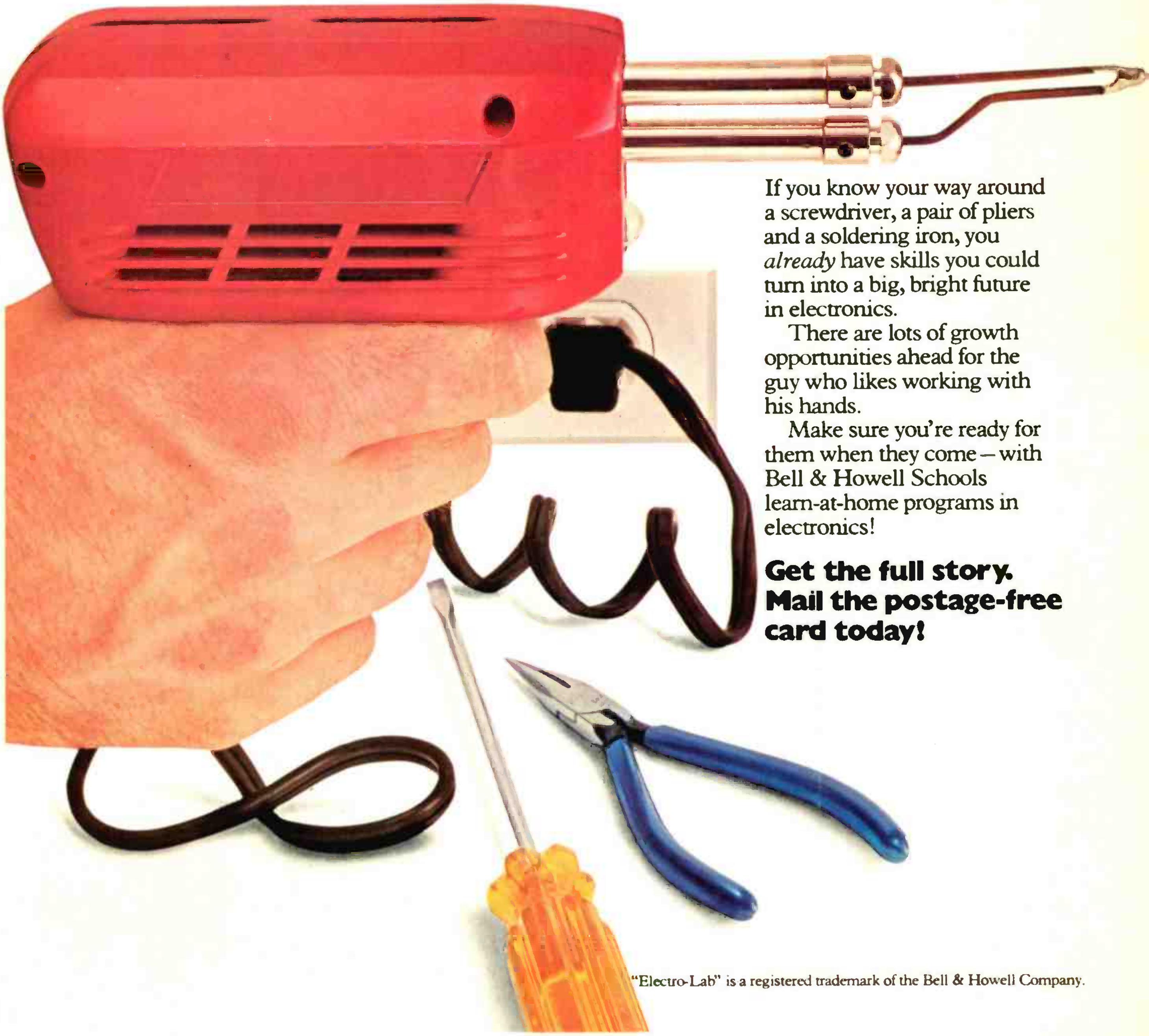
...You've got a head start on a rewarding career or a profitable business of your own in electronics. We've got two ways for you to make it happen. Which one's right for you?



If you know your way around a screwdriver, a pair of pliers and a soldering iron, you *already* have skills you could turn into a big, bright future in electronics.

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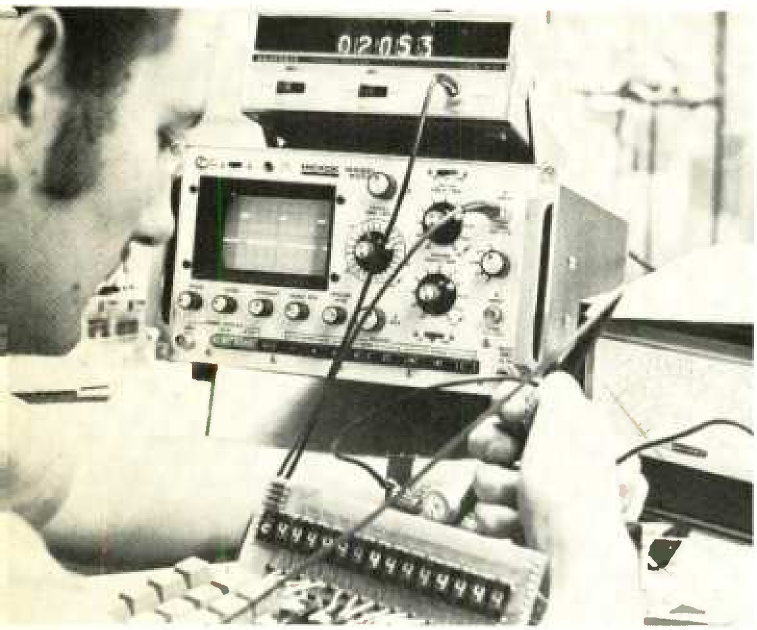
CALCULATORS



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 vom 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 vom 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 vom 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.

*Program Manager, Micro Instrumentation and Telemetry Systems, Inc., Albuquerque, New Mexico

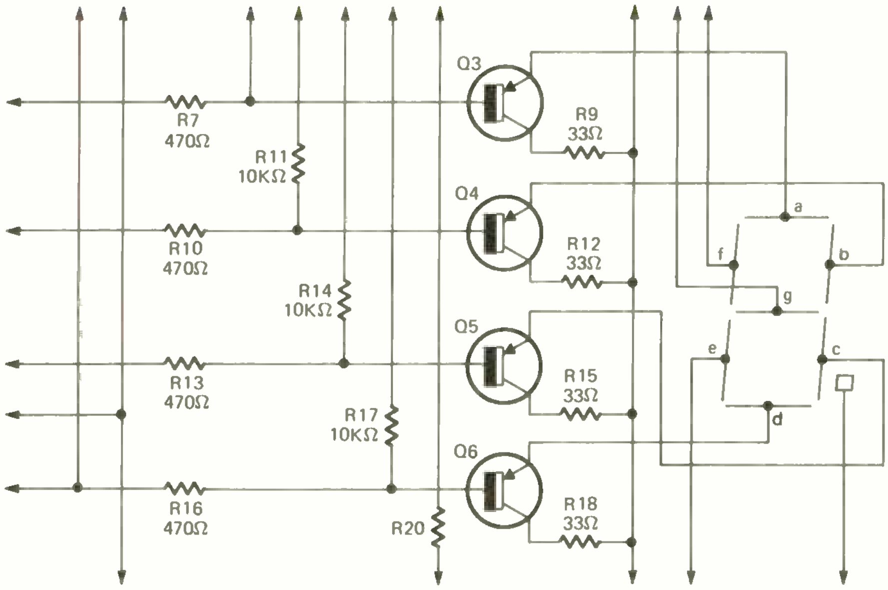


FIG. 1—PARTIAL SCHEMATIC OF DRIVER CIRCUIT for a seven-segment digital readout device. In the problem discussed in the text, the "C" segment of the readout does not light.

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_{GG} and V_{DD}. V_{GG} is a higher voltage and if open or shorted no entries are possible and an error indication is sometimes seen. With a missing V_{DD}, 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_{GG} and V_{DD} 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

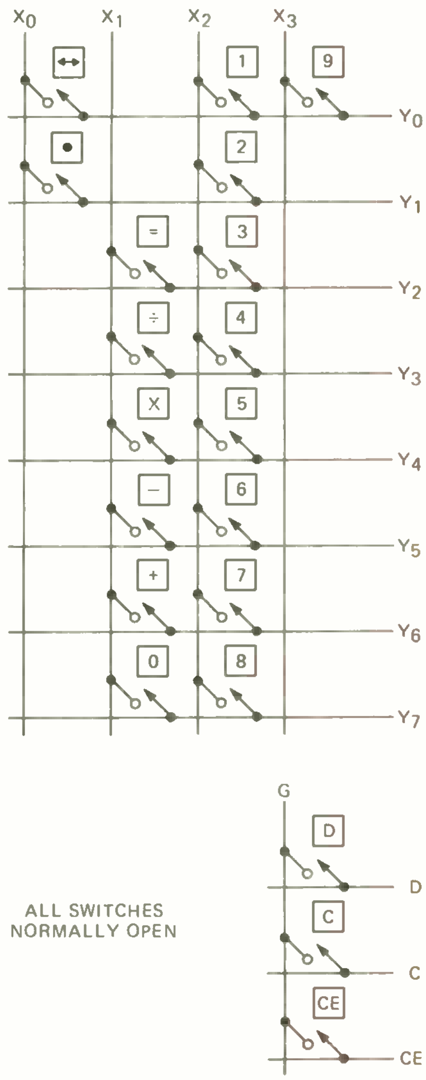


FIG. 3—MATRIX-TYPE KEYBOARD. Closing a key places pulses on the associated "Y" line.

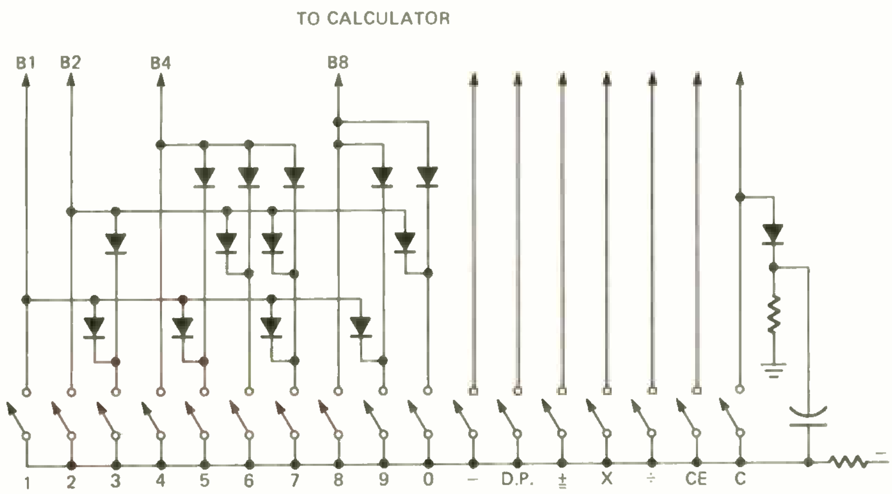


FIG. 2—DIRECT-INPUT KEYBOARD with the 0 to 9 keys connected through a diode matrix that provides a BCD output. An open or shorted diode causes errors in readout indication.

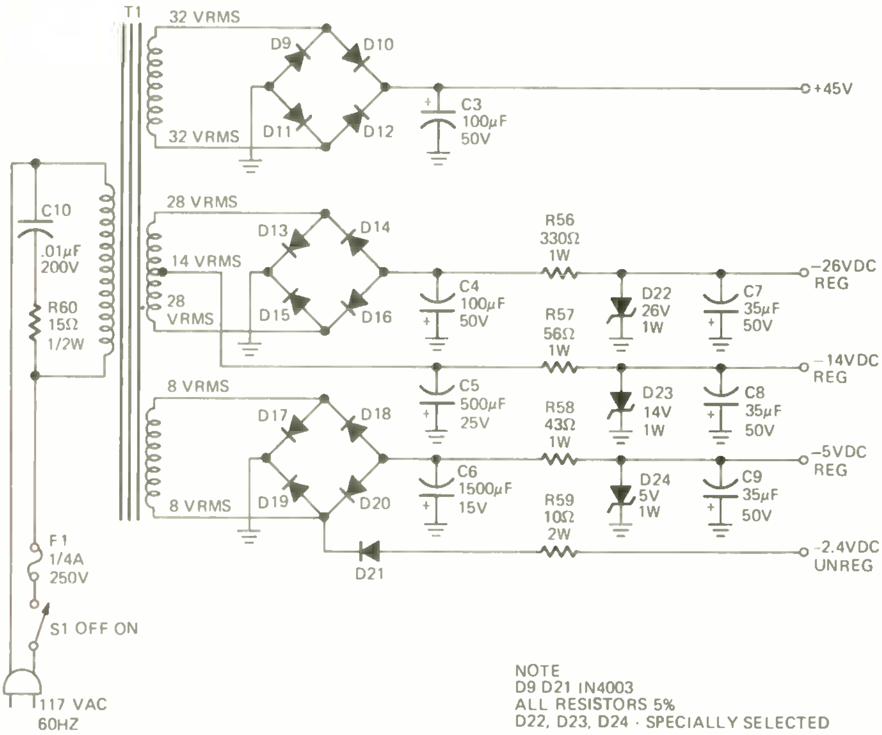


FIG. 4—A TYPICAL POWER SUPPLY FOR A DESK-TYPE ELECTRONIC CALCULATOR. The one shown is for the MITS model 816 and uses Zener diodes to deliver regulated voltages.

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.*

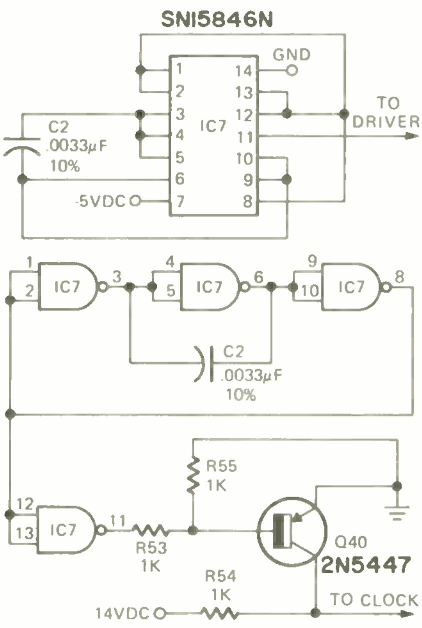
Display drivers

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

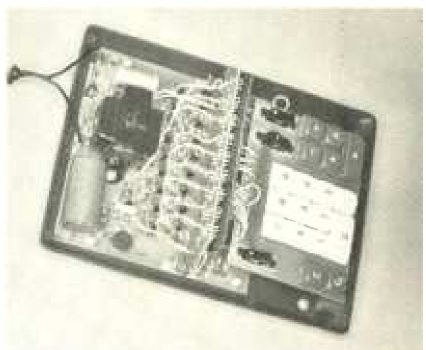
The digit drivers are fed from the output LSI chip, and their output goes to the anode of the display device. Fig. 6 shows a typical Darlington configuration used in most drivers. Initially the base of Q15 is positive with respect to its emitter and is driven into saturation. This turns Q16's base negative,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



NOTES
NOMINAL OUTPUT FREQUENCY 130KHz
ALL RESISTORS IN OHMS
ALL RESISTORS 1/2W, 5%

FIG. 5—TIMING PULSE GENERATOR is called a clock in calculator circuits.



INSIDE THE HEATHKIT IC-2108 calculator. Top of main board and rear of readout board shown.

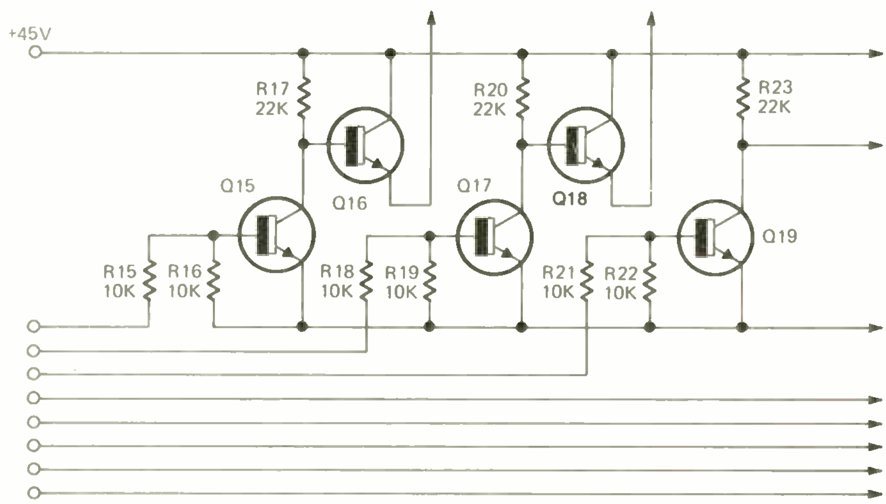


FIG. 6—THE DARLINGTON CONFIGURATION used here is typical of the amplifiers used in the digit drivers in calculators. A similar arrangement is used in some segment drivers.

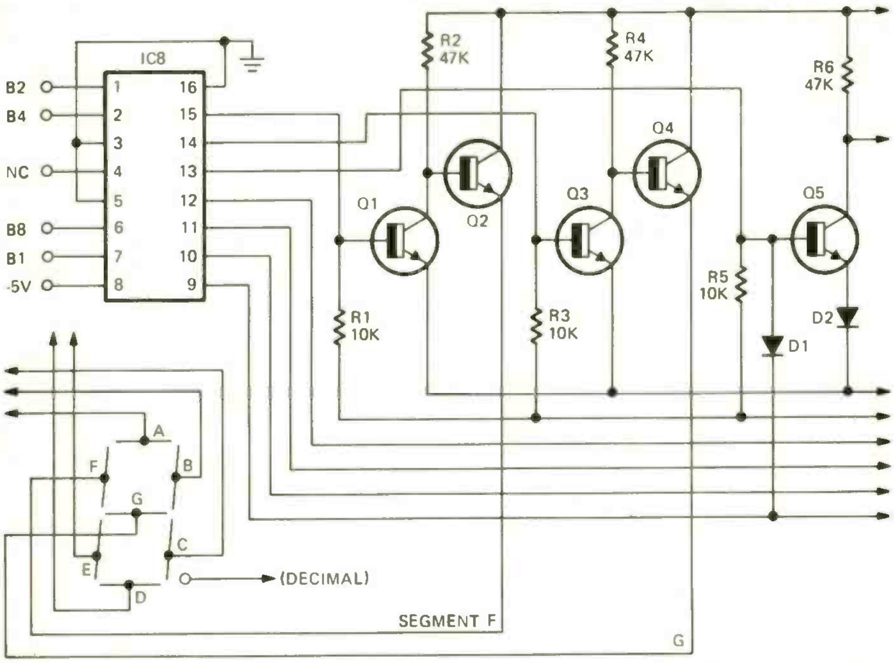


FIG. 7—BCD TO 7-SEGMENT DECODER. BCD input to IC8 (on pins 1, 2, 6 and 7) is converted to 7-segment data on pins 9–15. Transistor-pair drivers for segments F and G are shown.

TROUBLESHOOTING CHART

SYMPTOM	TROUBLESHOOTING PROCEDURE
No display or entry	Check: Power Supply Clear Circuit Clock Circuit
Overflow works but no display	Check: Power Supply LSI Chips (output)
Display always on or off	Check: Display Digit Driver Soldering LSI Chips (output)
Segment always on or off	Check: Segment Drivers Soldering LSI Chips (output)
More than one segment or display device on	Check: Soldering
Keyboard Switch failure	Check: Keyboard LSI Chips (input)
All digits on or off	Check: Power Supply
Random segments on	Check: LSI Chips (output) Segment Drivers
Function key failure	Check: LSI Chips (arithmetic)
Entries not possible (display normal)	Check: Keyboard LSI Chips
Constant function always on	Check: Constant Circuit and Switch LSI Chip (input)
Display warms up and turns off	Check: Soldering LSI
Display flickers	Check: Power Supply
Error indicator on and no entries possible	Check: Power Supply

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 0V. If a 2, for example, is entered on the keyboard, it will appear on the four BCD lines as: B1 = -5V; B2 = 0V; 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 0V. 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)

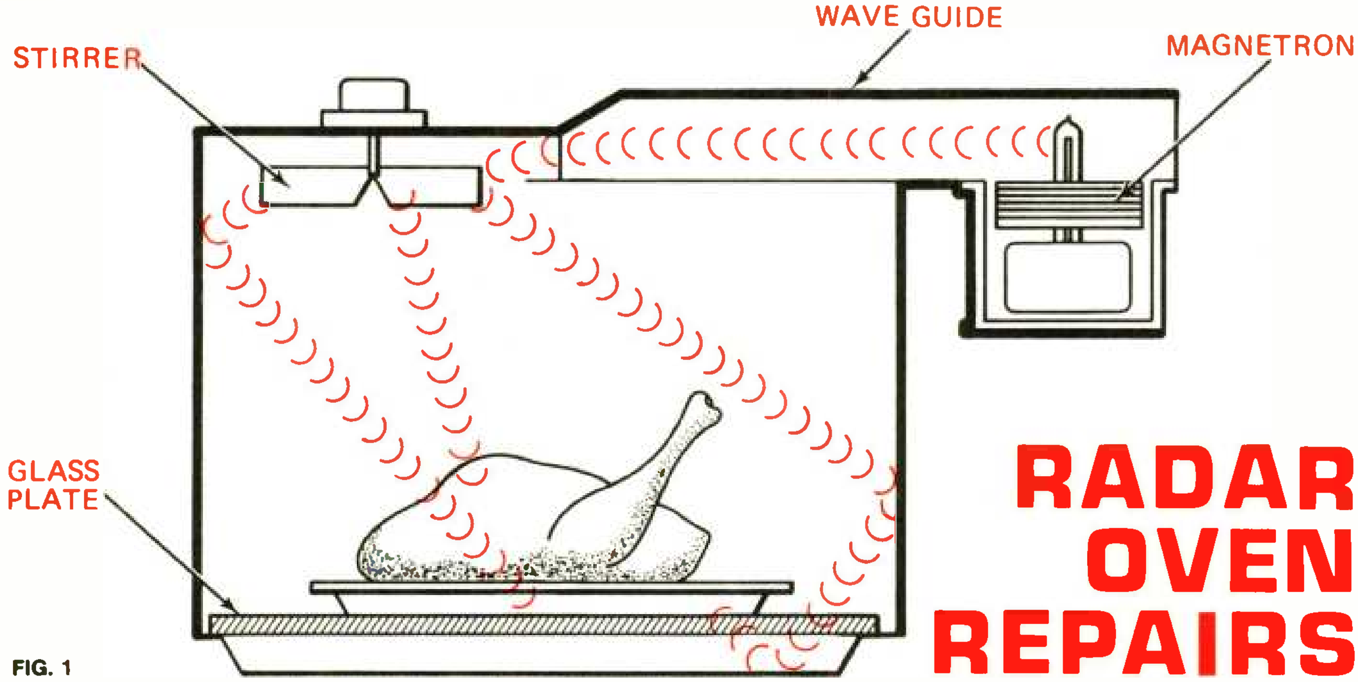


FIG. 1

RADAR OVEN REPAIRS

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 servicemen 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.

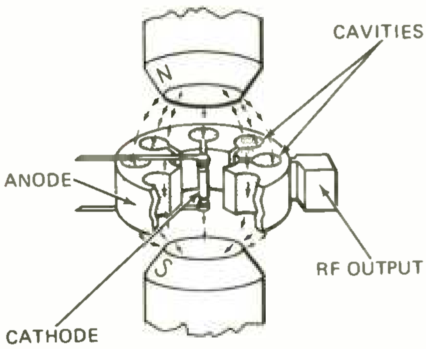
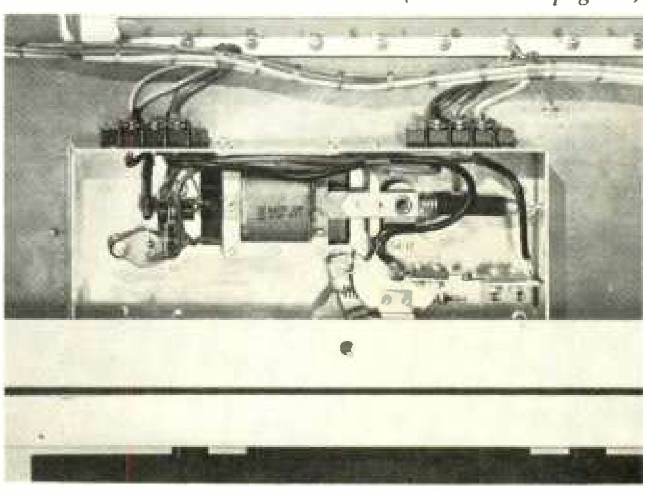


FIG. 2—DIAGRAMATIC REPRESENTATION of a magnetron. Its operation depends on a strong magnetic field developed by a permanent magnet or electromagnet.

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.

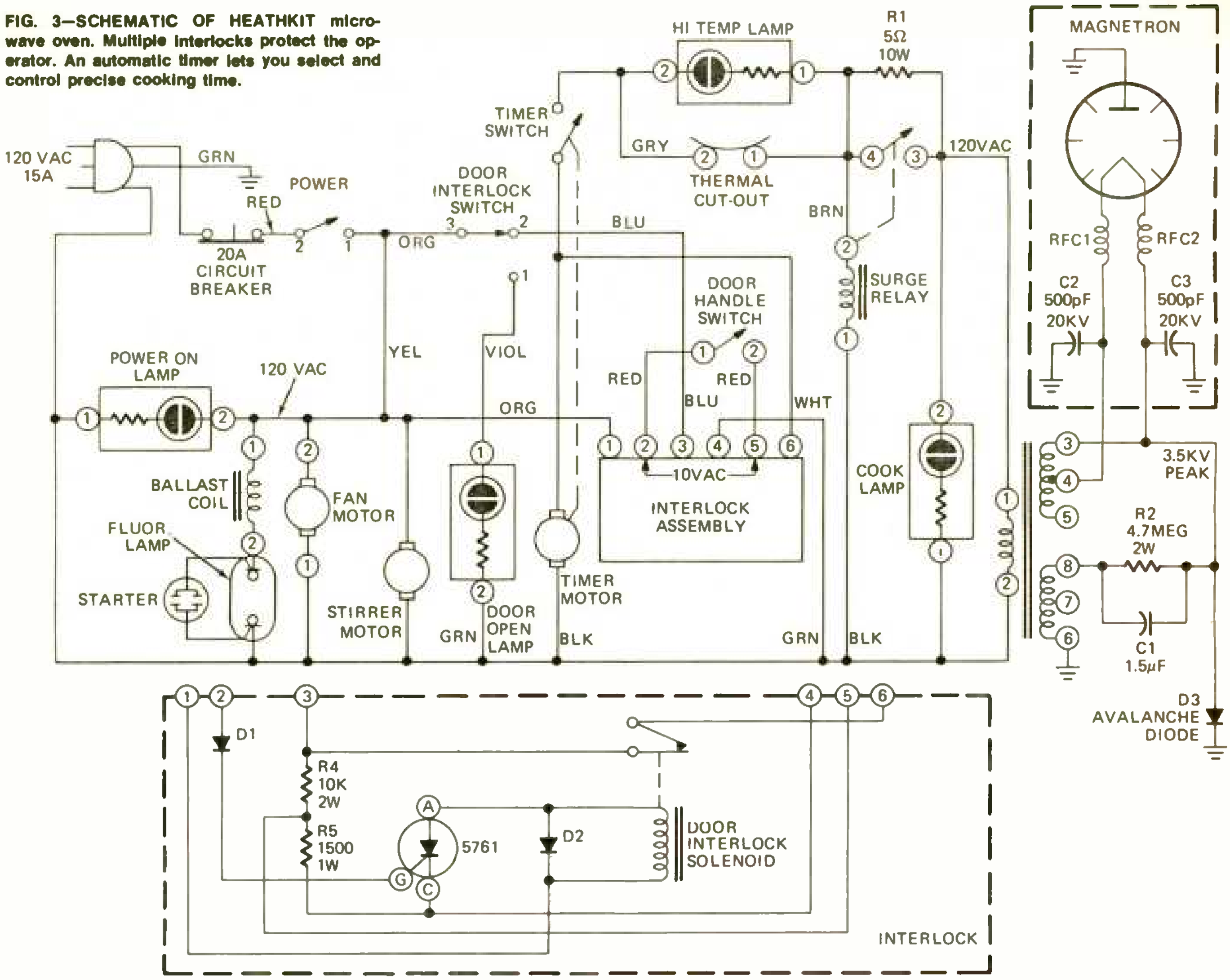
As can be seen in the typical schematic of Fig. 3, most ovens also have a timer that turns the oven off when cooking is completed, a fan that

(continued on page 42)



DOOR INTERLOCK on Heathkit oven prevents the door from opening until high-voltage to the magnetron is turned off.

FIG. 3—SCHEMATIC OF HEATHKIT microwave oven. Multiple interlocks protect the operator. An automatic timer lets you select and control precise cooking time.



cools the magnetron assembly, and a series of interlocks and thermal relays designed to shut down the oven when the door is opened or the magnetron temperature climbs too high. Microwaves can be dangerous—they make no distinction between heating food or heating flesh, and we know that microwave energy is particularly damaging to delicate areas of the body, such as eye tissue.

Testing the control circuitry

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 1½ 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:

$$P = (T2 - T1 \times 35)$$

where

P = power in watts

T2 = temperature in °C after heating

T1 = 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

MICROWAVE OVEN is Heath's GD-29 kit. Four panel lamps show operating status at all times.

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).

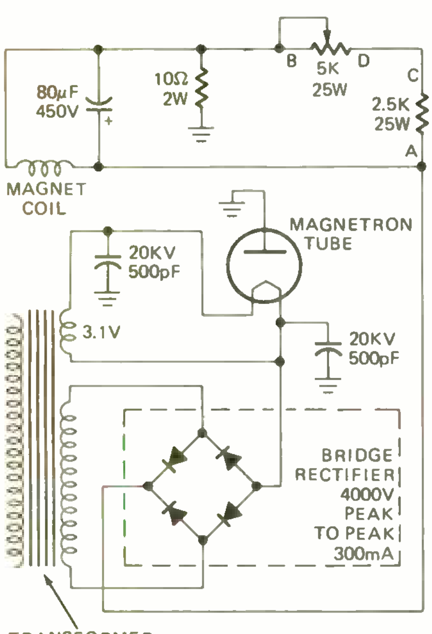


FIG. 4—MAGNETRON POWER SUPPLY. Current through electromagnet is adjustable so you can set magnetron's anode current.

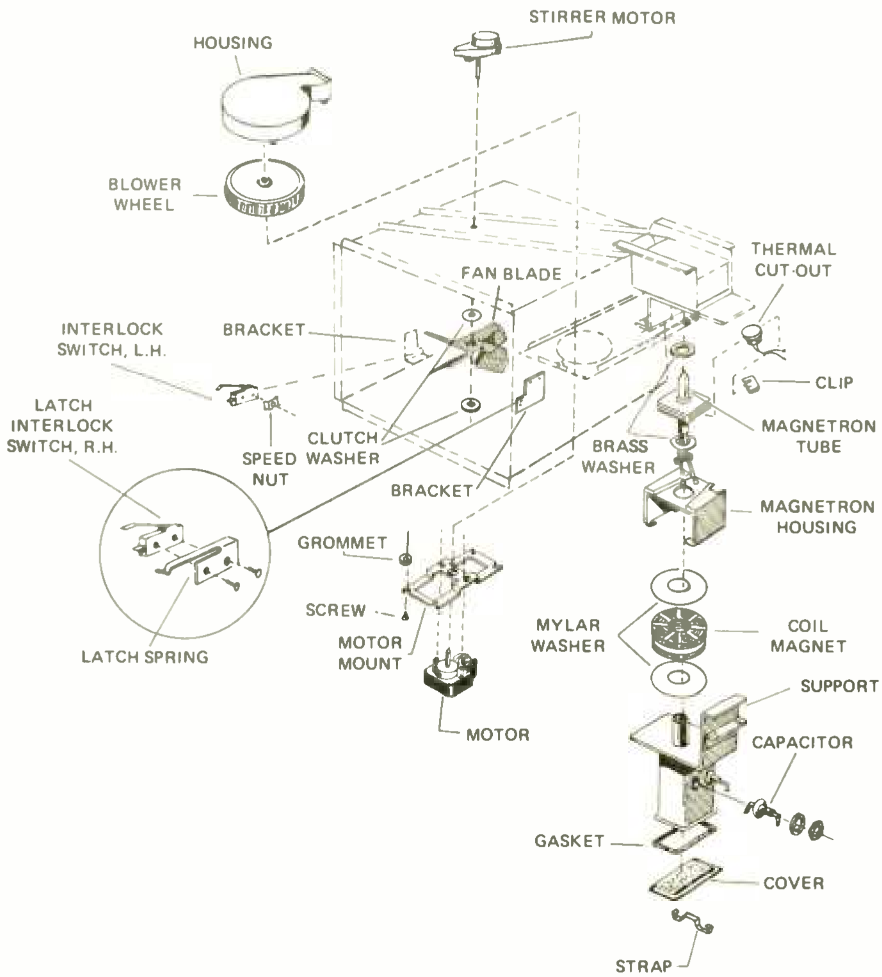


FIG. 5—EXPLODED VIEW of typical microwave oven and magnetron assembly. You'll need this sort of information when removing a defective magnetron and installing a new one.

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.

THIS MICROWAVE OVEN, Micromite model 2000 has timer dial and see-through oven door.

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

(continued on page 47)

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 stopwatch and put on my best radio-announcer'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 to: (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-

SHE WON'T MISS ANOTHER CALL with the Dictaphone Ansafone 640 answering device.

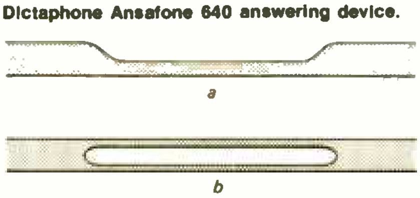


FIG. 1—REDUCED TAPE WIDTH (a) and a slot in tape (b) are two ways of controlling the recorders.

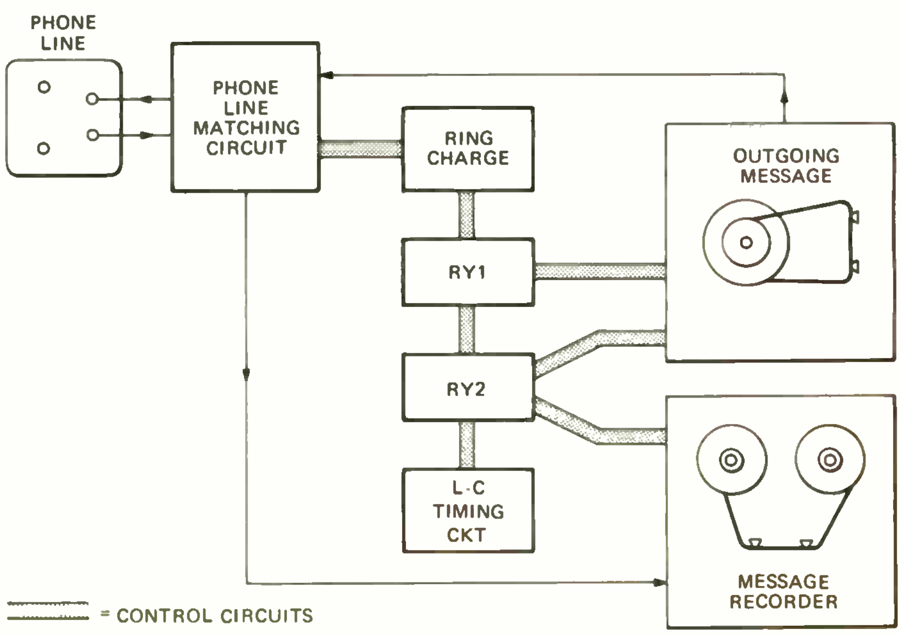


FIG. 2—BLOCK DIAGRAM of a typical telephone answering machine connected to the incoming telephone line. Some message recorders use cassettes for quick removal and storage.

telephone answering robots

An automatic telephone answering machine is a boon to small businesses and to anyone who cannot be at his phone at all times. Here is what they are all about.

by EUGENE WALTERS

going recorder and closing RY2, which latches. RY2 triggers a short oscillator tone burst (the "beep"), powered by a stored capacitor charge, and starts the message recorder—a rim-drive unit that runs at approximately 3¾ ips. At the same time, an L-C circuit 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 phone 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 ordinary extension telephone. It's usually at a telephone location, and a "sandwich" phone plug is supplied which plugs into a standard telephone company 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 connection, 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.

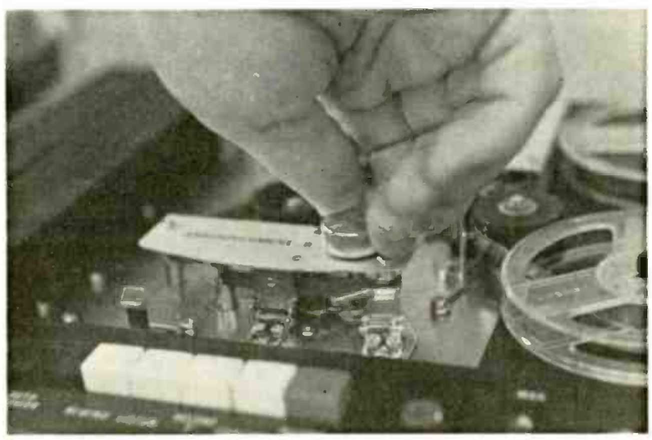
Tapes can be changed when worn or damaged. Or for that matter, the outgoing message tape can be shortened easily, simply by snipping out some tape where the leader is spliced in, removing a turn or two of tape, and resplicing. Thirty seconds does seem overlong for an outgoing message.

Other low-cost phone-answering systems are packages of electronics that require the addition of a standard tape recorder to take messages. Such machines have an outgoing message recorder, and most of the electronics shown in Fig. 2, but don't have the message recorder. Connecting cables are provided, and the recorder that's used for this purpose must be left in the "record" position permanently.

There are several limitations to most inexpensive machines. For one thing, there's the 30-second limit on phone messages; also, the message tape can't be easily removed for file storage or later reference; and there's the unit's limited capacity—30 messages total is plenty for the consumer, but possibly not for business.

To avoid these problems, a more sophisticated (and more expensive) system 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 (3¾ ips, capstan driven) or on a standard cassette—and in either case, the tape can be quickly removed for storage. The outgoing message 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



RECORD-A-CALL UNITS (right) give operator a choice of three outgoing message channels. A flick of a switch selects the desired message by moving the head assembly.

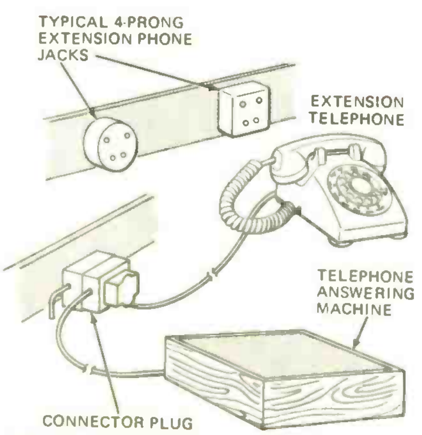


FIG. 3—CONNECTOR PLUG is a handy adapter to interface line and answering device.

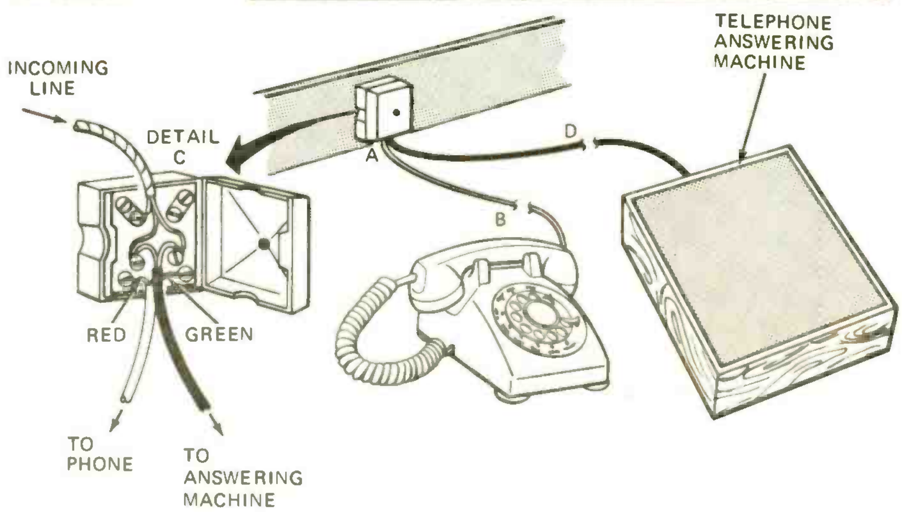


FIG. 4 (below)—HOW TO HOOKUP ANSWERING DEVICE to a phone not equipped with a plug-and-jack connection. The phone line may be direct or patched through a switchboard.

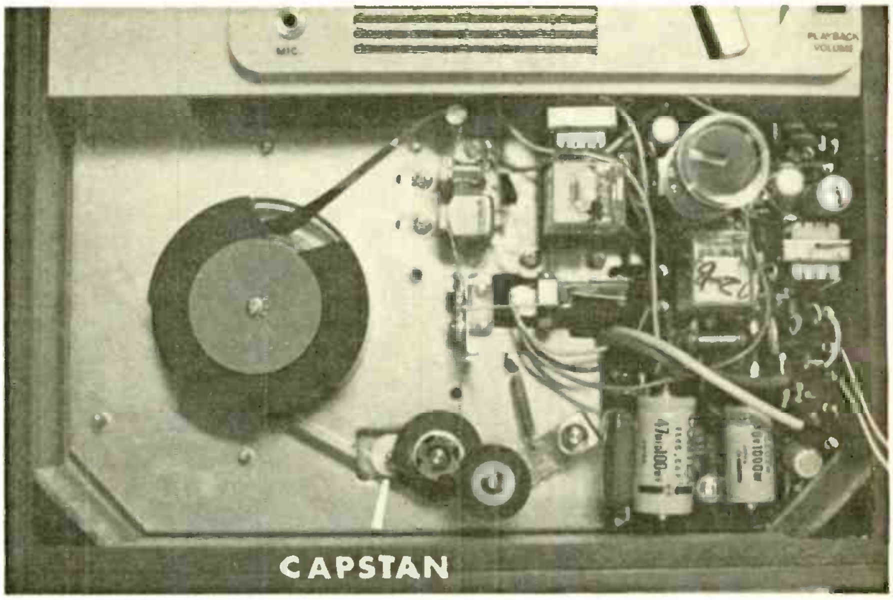
up for three-channel operation; a selector knob picks one of the three tracks, marked for alternate messages. Thus, the user can change outgoing answering messages by turning the selector knob. This change in message capability is especially important for professional offices, where a doctor may be on 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.



OUTGOING-MESSAGE TAPE and electronics of Phone Mate telephone answering machine. Pinch roller is always against the capstan and can cause flats to develop on it.

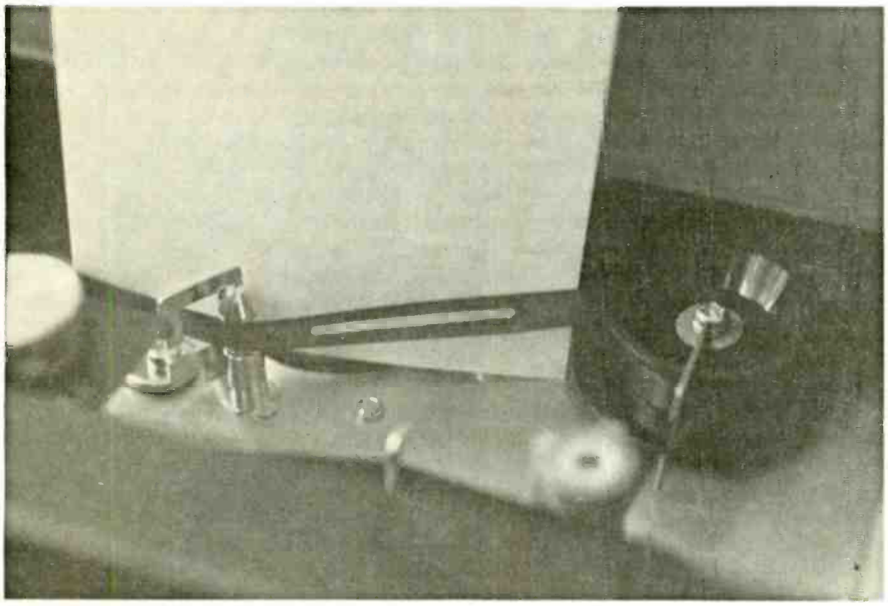
THE GEMINI, by Record-A-Call uses physical lift unit and offers a choice of acoustic or inductive coupling so there is no need for direct electrical tie to phone line.

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.

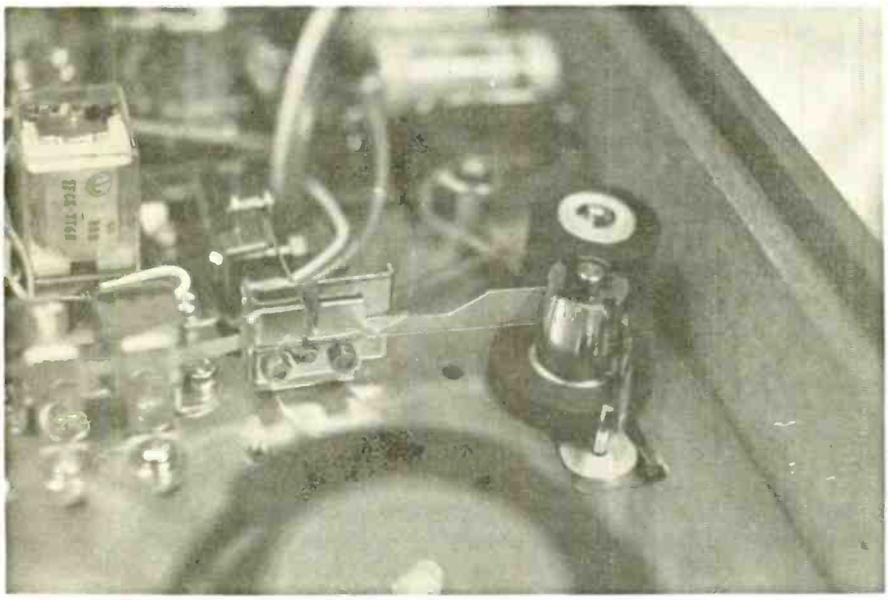
The low-cost phone-answering machine has its place in the scheme of things. These machines, because of their low cost, are appealing to the consumer, hobbyist and private citizen who would like to have his phone answered on a 24-hour-a-day basis.

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.

a plug-in, add-on module. Incoming messages are recorded as usual, but when the owner calls in and beeps his electronically coded remote "key" into the telephone, the machine plays back its messages.

Some remote units have extra features, such as keyed backup for repeating hard-to-understand or complex messages. In all cases, a special electronic "combination" code is used to trigger the unit—a different combination for each one.

One recurring problem is the robot user who leaves and forgets to turn the machine on. Obviously, the unit can't answer the phone if the switch is turned off. But there's an answer to that one, too. There's a unit soon to appear that will turn itself on after the fourth ring, so it simply can't be forgotten. R-E

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-wave slot around the inside of the door. As you can see in Fig. 6, this is

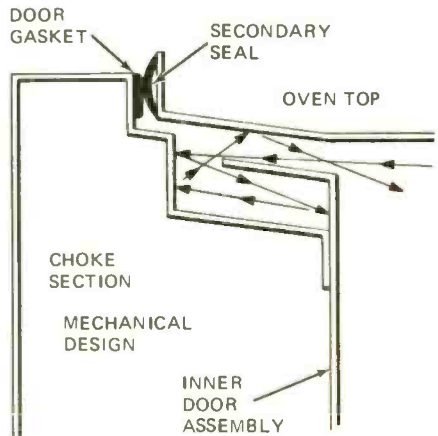


FIG. 6—RADIATION FROM INSIDE OVEN is prevented by a quarter-wavelength slot or trap section around the door perimeter.

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 all 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

(continued on page 90)

Experiment with WWVB

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

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 topical 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 0303-0866. 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 13,000 watts. Field strength contours for the United States are shown in Fig. 1. Except for the code modulation we'll tell you about in a minute, the signal is all carrier—there are no voice announcements, no tics, geoalerts, 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 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, along with the complete code.

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 "minutes," and another P pulse at ten sec-

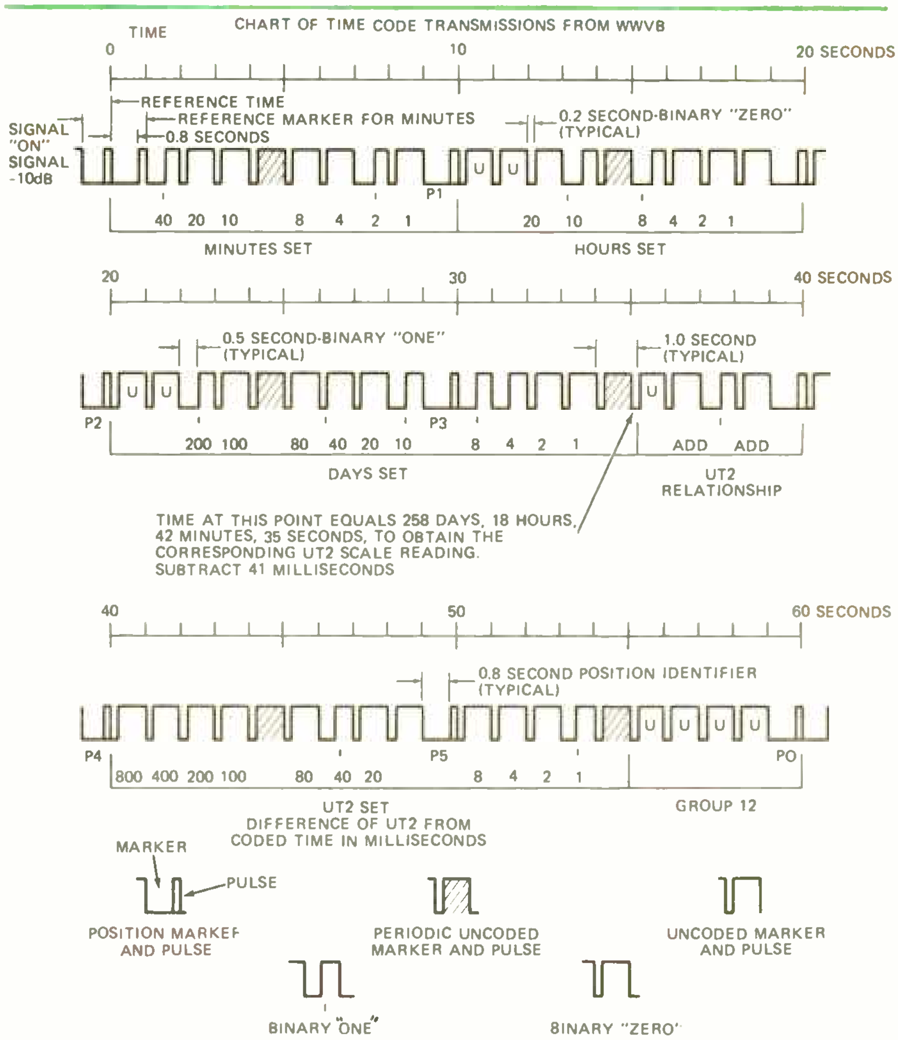


FIG. 2—PULSES AND TIME CODE broadcast by WWVB on 60 kHz from Ft. Collins, Colo.

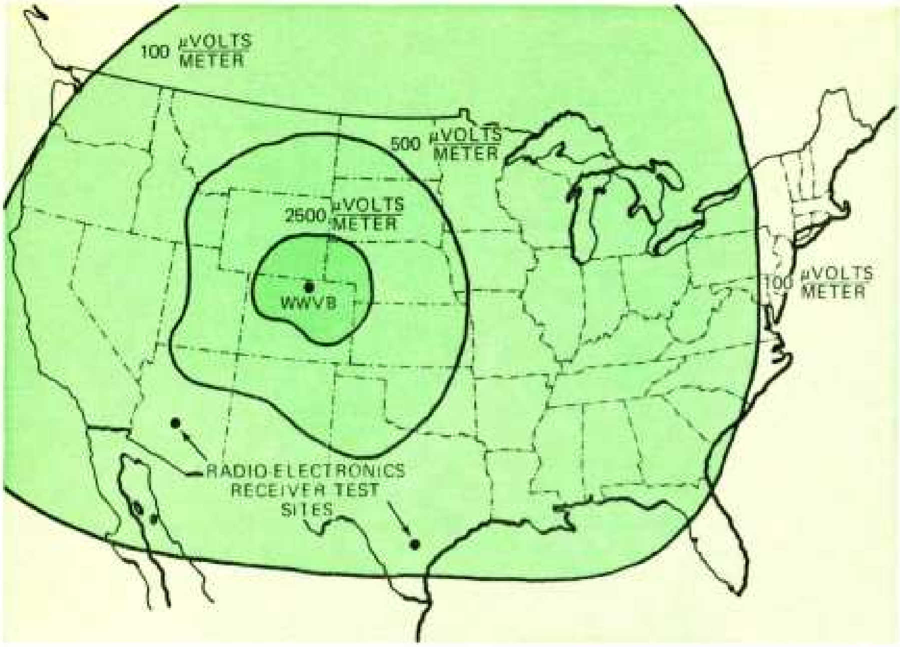
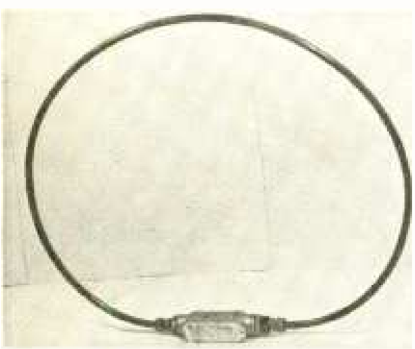


FIG. 1—SIGNAL STRENGTH of WWVB broadcast over the continental U.S.

onds. 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 automatically takes care of the 2400 hour GMT to local time conversion.



TRADITIONAL LOOP ANTENNA. Note insulating section on shield.

So, to get from WWVB to a Superclock update, we need a 60-kHz *receiver* that picks up the signal and converts it to a reliable string of "1"s and "0"s. Then we need a *decoder* that converts the "1"s and "0"s into a proper format and decides when the Superclock is to be updated. The decoder is easy and reliable—the problem is the receiver.

WWVB is completely free from fading and keeps a remarkably stable output, except for a short diurnal variation for a few minutes at local dusk and dawn. The low frequency allows very accurate timing information with the whole world behaving as a waveguide to bring the signal to you without any of the problems common to the shorter wavelengths. There's almost always enough signal. The problem is that WWVB is an AM system at low frequency and there is substantial terrestrial and manmade noise, particularly near thunderstorms 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.

WWVB PREAMP is in the loop antenna. It should be completely shielded.

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 S 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 shock-proofing 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.

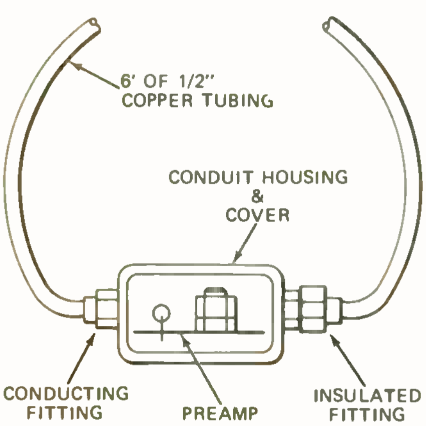


FIG. 3—SHIELDED-LOOP ANTENNA for receiving WWVB broadcasts.

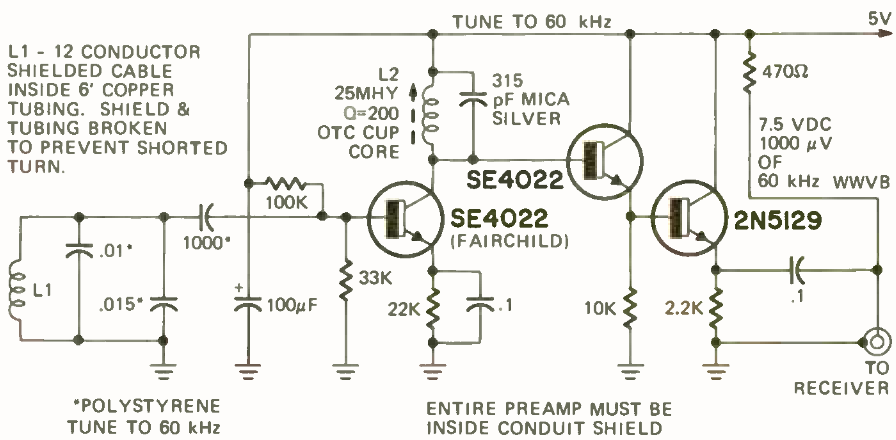


FIG. 4—PREAMP SCHEMATIC. Three-transistor circuit is easy to build and inexpensive. Total cost is about $8.

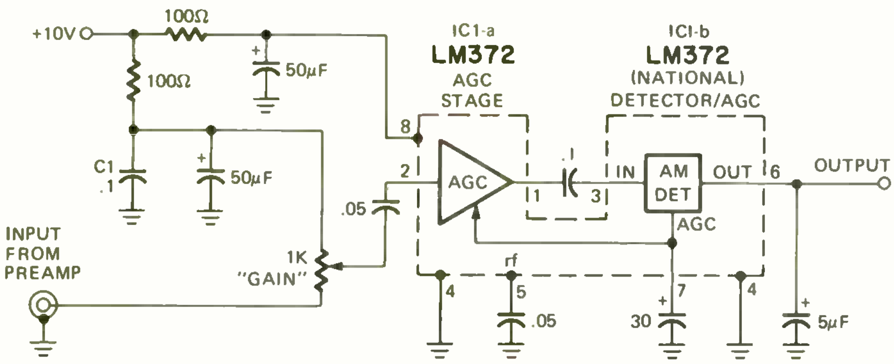


FIG. 5—A SIMPLE WWVB RECEIVER can be built around a National LM372 IC. Just follow this basic schematic.

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 mHy.

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 so 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 vom. 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 capacitor 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 vom. 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 help. 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

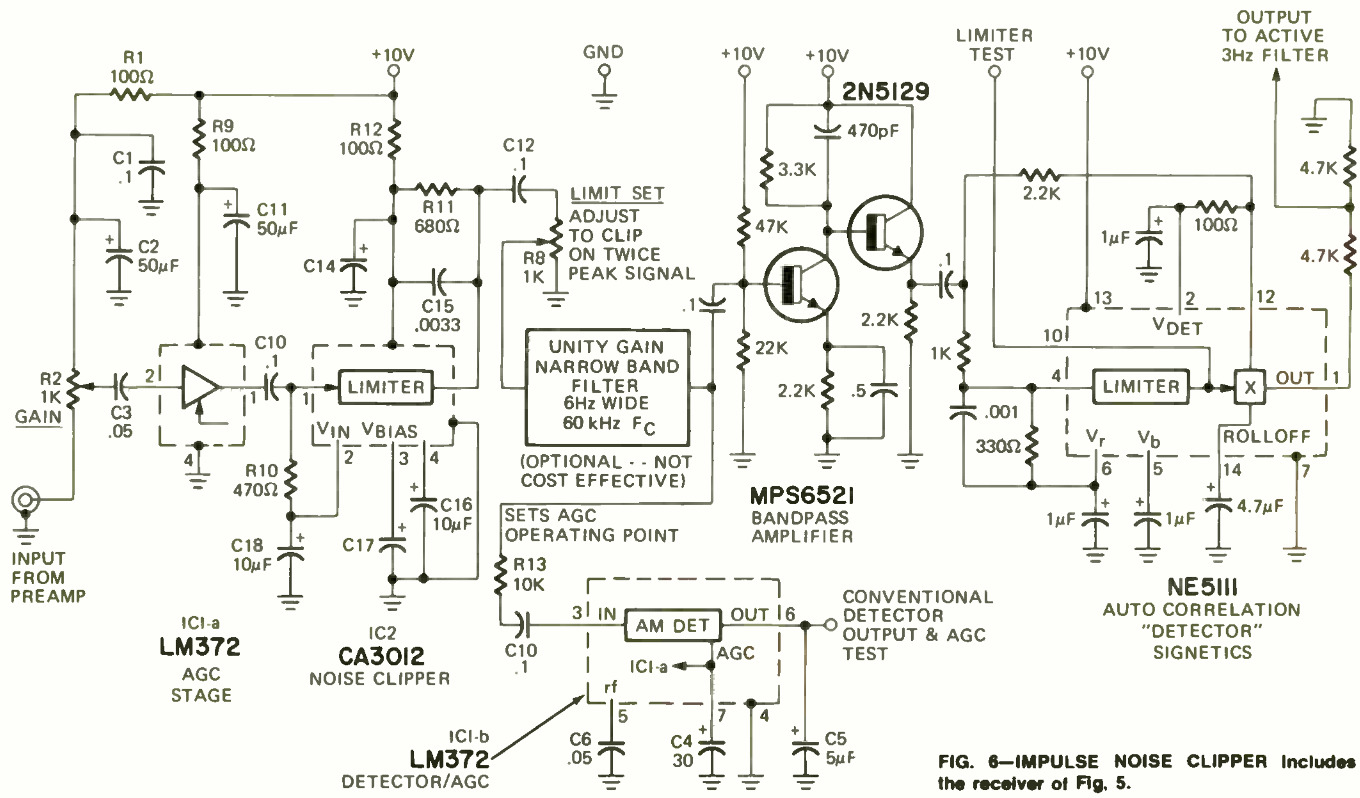


FIG. 6—IMPULSE NOISE CLIPPER includes the receiver of Fig. 5.

in the circuit. The limiter has to be inside the agc loop, and the inside gain has to be adjusted so that limiting takes place at twice the normal signal level over the normal operating agc range. Once set properly, the agc 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 preamp.

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 $\sqrt{100}$ or a factor of 10. This is how the simple receiver of Fig. 5 does the job.

2. If you do your filtering *before* detection, you will 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.

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.

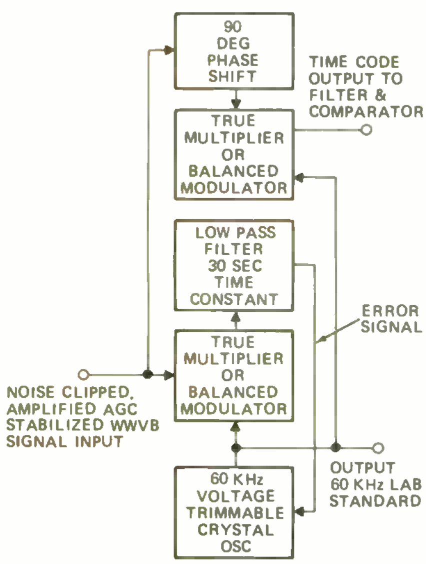


FIG. 7—VARACTOR-TRIMMED CRYSTAL oscillator improves noise 3 dB.

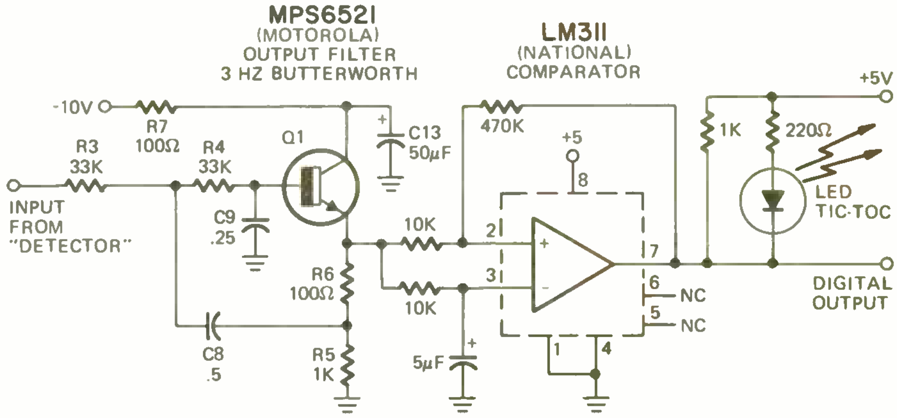


FIG. 8—LOW-PASS FILTER is used to filter the output. Gives a dB or two of additional improvement.

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, magnetostrictive 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 cost effective and could cause oscillation and shielding problems. 60-kHz crystals have too *high* a Q, even if you let air into the can to damp them, although a pair of crystals properly stagger tuned probably would work. Again, it's not 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* detection. 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 *Phaselock 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 other 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.

EXPERIMENTAL SUPER-LOOPSTICK is shown less shield. Rods are 5¼-inch long. Figure of merit is around 2. Resonating capacitor is around 235 pF.

TECHNIQUE No. 3—*Filter the output sharply.* If we only need 3 Hz bandwidth to get the signal we want, anything else beyond 3 Hz is noise. If your filter falls off slow, you pick up extra noise. So, use a second order low-pass like the one in Fig. 8. It only buys you a decibel or so of improvement, but it's simple and cheap. Fig. 8 also shows a comparator that converts the analog code to digital logic levels.

Once again we've just run out of space and cannot complete this article till next month. In the September issue we will present details of an improved receiver and a decoding circuit including two more schematics.

Lee de Forest

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.

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

by FRED SHUNAMAN

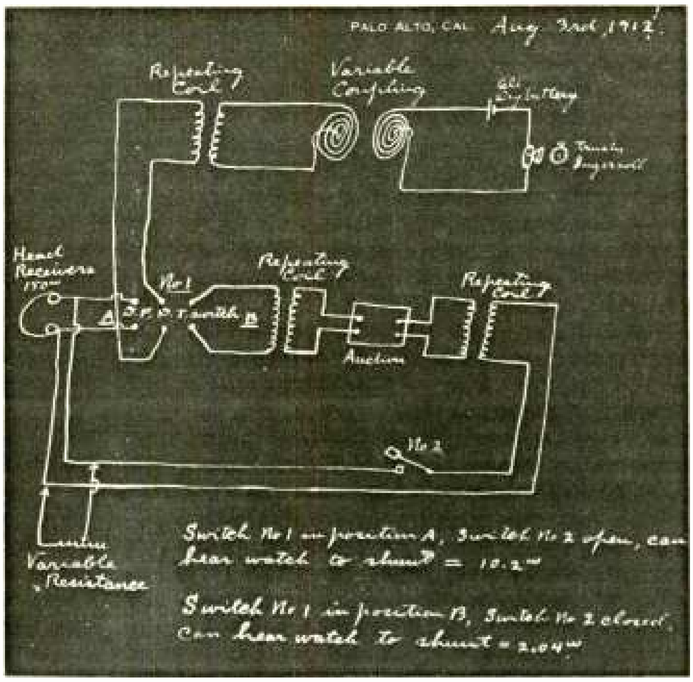
LEE DE FOREST—LIKE TOO MANY OTHER figures in the history of electronics—is already becoming a victim of neglect by those who write the histories of radio. Given the honorific "Father of Radio" for his invention of the Audion amplifying vacuum tube, practically none of his other work is mentioned—nor 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

100th Anniversary



→ **SCHEMATIC OF THE FIRST AMPLIFIER ever constructed. "Repeating coil" is an old telephone term for transformer. The circuit was made so strength of the signal can be varied and has a variable resistor shunt for phones so amplified and unamplified signals could be compared.**

← **HUGO GERNSBACK, founder of this magazine, as he presented in 1947, a copy of the special "de Forest" issue to Dr. de Forest. The Jan. 1947 issue of Radio-Craft marked the 40th anniversary of the triode vacuum tube.**

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 promotor, 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—as some say—simply an improvement on the Fleming valve ("de Forest inserted a third electrode") or was it an entirely separate invention?

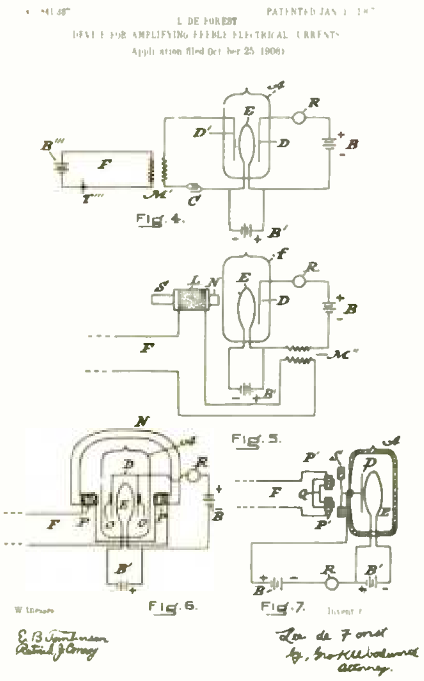
The answer is that the Fleming valve and the de Forest Audion are not only two distinct inventions, but belong to two different families of detection devices. The Fleming valve is a rectifier. As such, it takes its place with Fessenden's Wollaston wire detector and the crystal detectors of Pickard and 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 Branly 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, that 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. He then 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



PATENT DRAWINGS used to illustrate the principles of an early vacuum-tube amplifier patented by Dr. Lee de Forest in 1907.

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; Guantanamo, Cuba; and Colon, in the future Canal Zone.

In 1906 de Forest first ran afoul 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.

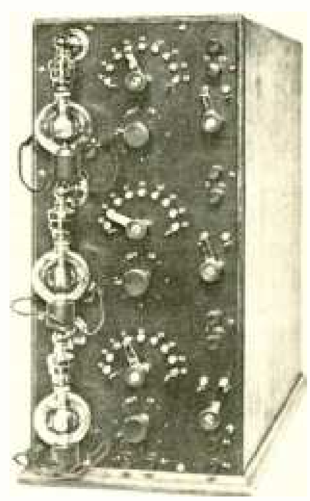
While working on the amplifier, de Forest and his assistants one day connected the output of the second stage back to the first. That historic day, August 16, 1912, was the birthday of feedback, regeneration and oscillation. They heard (and described in van Etten's notebook) a high musical note as a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



THIS THREE-STAGE AUDION AMPLIFIER was first built in 1912 by the Federal Telegraph Co. (predecessor of ITT) during the period that de Forest was the head of the research department. The earliest known commercial cascade amplifier, it had a gain of 120. It was first demonstrated to the United States Navy in September of 1912.

A fraud case came to trial late in 1913. Some of the stock-jobbing directors of the company were found guilty and sent to Federal prison. The jury found de Forest innocent, even though the prosecutor produced unassailable proof that de Forest had 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 the first newscaster, announcing the results of the 1916 Presidential election (four years before KDKA's heralded broadcast). The High Bridge station closed at the outbreak of World War I.

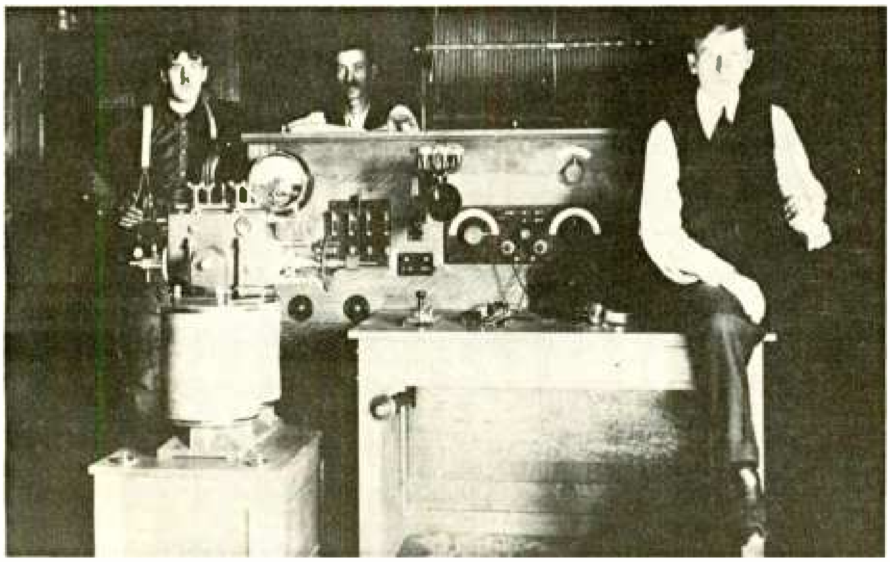
By 1916 the Telephone Co. had decided it needed still more rights in the Audion, and re-opened negotiations. Finally, de Forest sold all rights in the Audion and in radio service for public pay, plus rights in all patents pending and to be filed during the next seven years. The price was $250,000. The 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 commerical and legal competitors.



SOUTH SAN FRANCISCO STATION of the Federal Telegraph Co., as it appeared in 1912. The station is fitted for duplex operation as developed by Dr. de Forest, with two identical 30-kW transmitters taking turns on one antenna.

To get capital for his sound-on-film work, he had sold control of the de Forest Radiotelephone 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 forseen 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—on 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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STATE-OF-SOLID-STATE

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

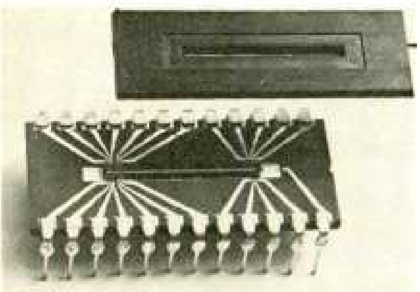


FIG.1—FAIRCHILD'S NEW CCD image sensor linear array.

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.

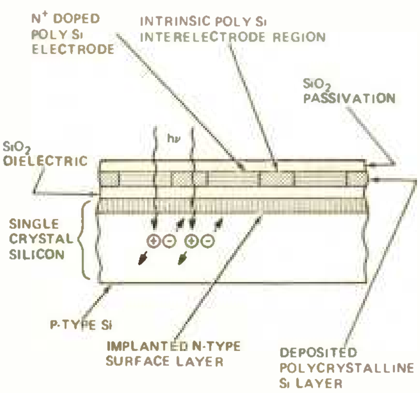


FIG. 2—CROSS-SECTION SKETCH showing layered construction of the new CCD image sensor.

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-

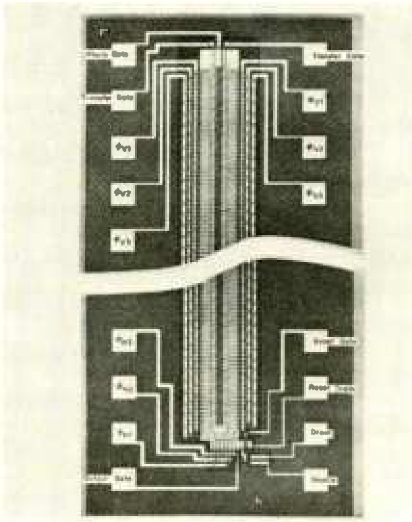
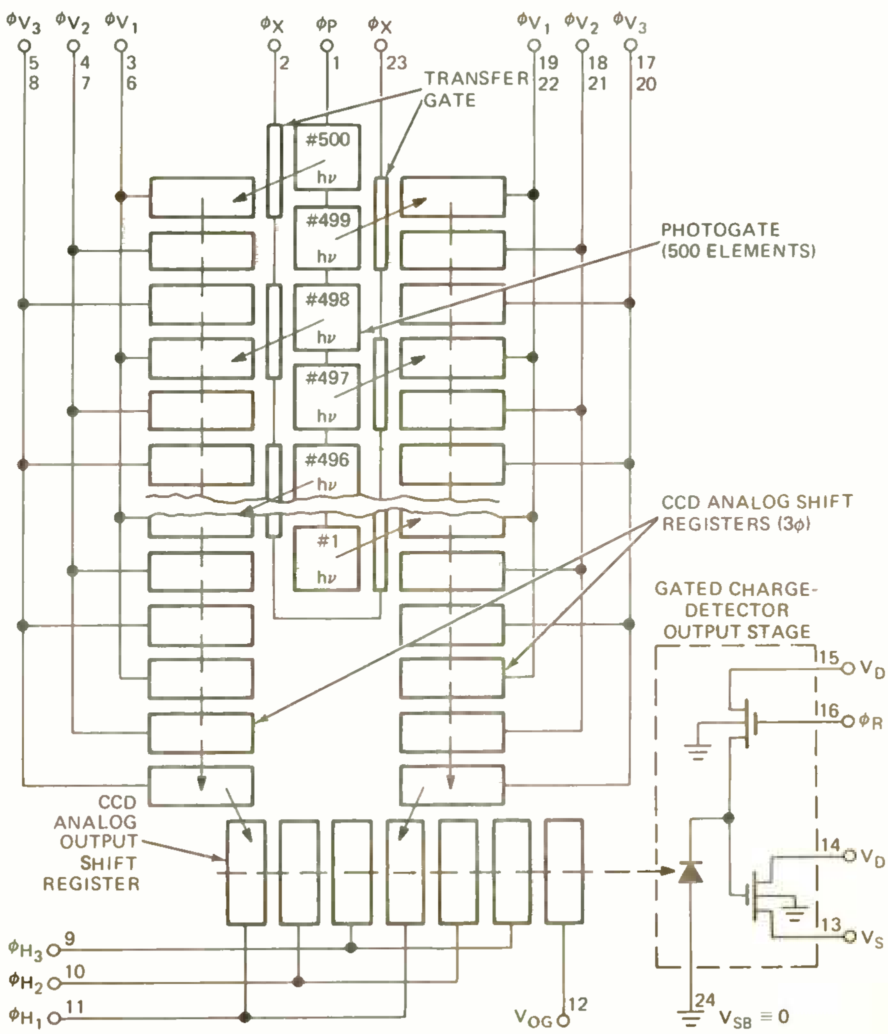


FIG. 3—PHOTOMICROGRAPH (left) of Fairchild's new device.

FIG. 4—CCD IMAGE SENSOR SCHEMATIC.



The growth of the semiconductor industry and the development of new devices is ever expanding. Read all about some of the most interesting new devices and developments

by LOU GARNER
SEMICONDUCTOR EDITOR

trol 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 interleaves 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 line of linear and Hall Effect IC's, functional electronic circuits, thin-film resistor arrays and hybrid circuits, and digital and logic devices. The catalog includes device specifications, terminal connections, internal schematic diagrams, package outlines and suggested applications.

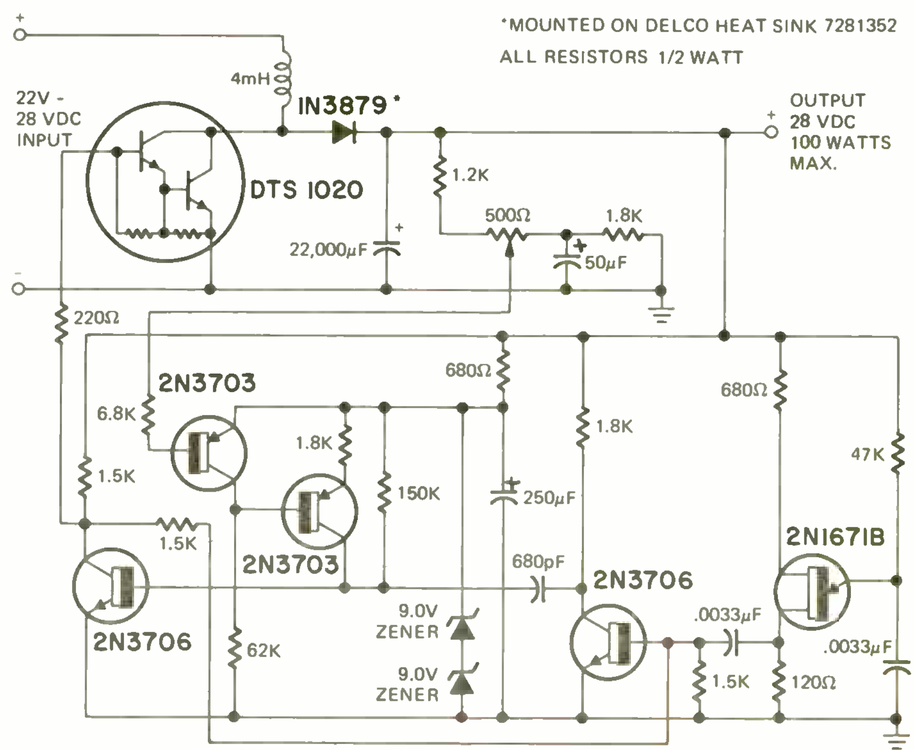


FIG. 5—28-VOLT SWITCHING regulator circuit abstracted from Delco Application Note 49.

turing 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

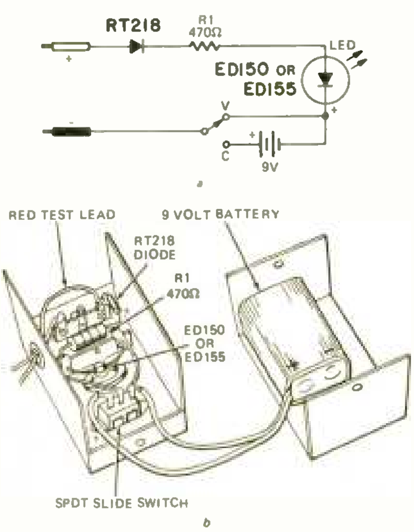


FIG. 6—SCHEMATIC (a) AND CONSTRUCTION details (b) for voltage/continuity tester described in Sprague Application Note.

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 (620-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 MOSFETs 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

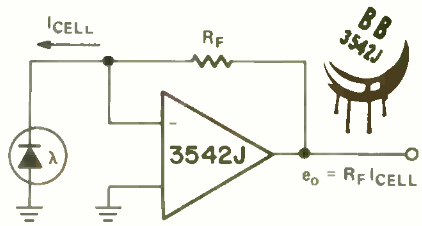


FIG. 7—BURR-BROWN'S NEW lost-cost FET op-amp IC used as a photocell amplifier.

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-to-supply-voltage protection are provided in the unit.

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.

FIG. 8—RCA'S NEW MULTI-PURPOSE 7-amp hybrid amplifier.

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 41014 and 41015, 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 (41014) and 400 volts (41015).

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. **R-E**

how it works

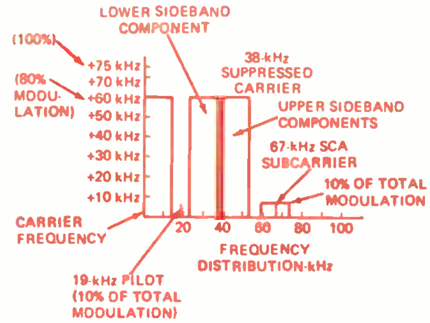


FIG. 1—SPECTRAL DISTRIBUTION of FM stereo composite signal. Note the SCA subcarrier at the right.

New FM Stereo Decoder

Phase-lock-loop circuits are not new, but a PLL IC used as the FM multiplex detector in a FM stereo tuner is. See how this new circuit works

by LEONARD FELDMAN
CONTRIBUTING HIGH-FIDELITY EDITOR

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 supressed. 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 supressed 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 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 supressed-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 that 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.

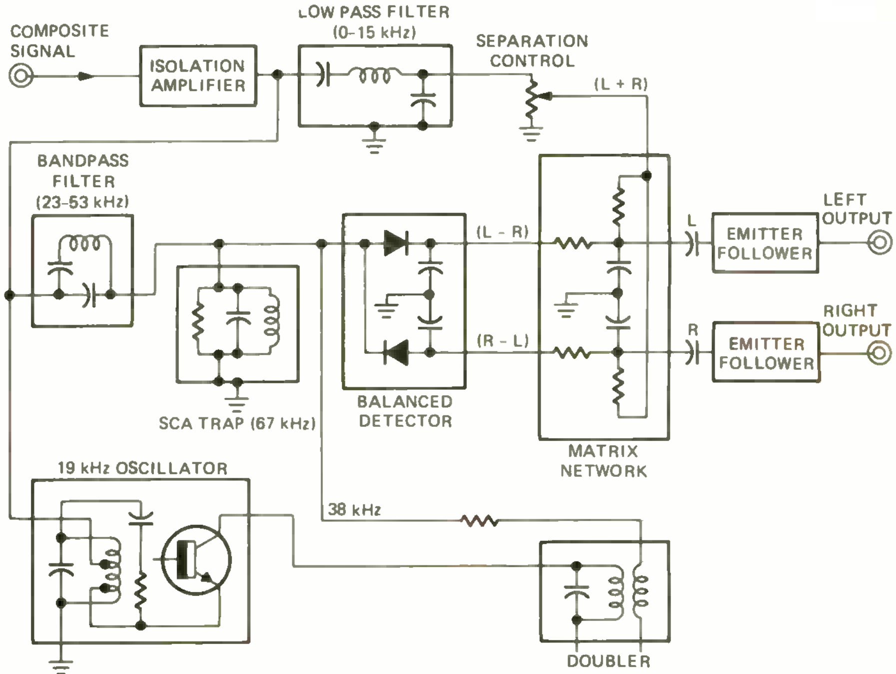
The phase-locked loop

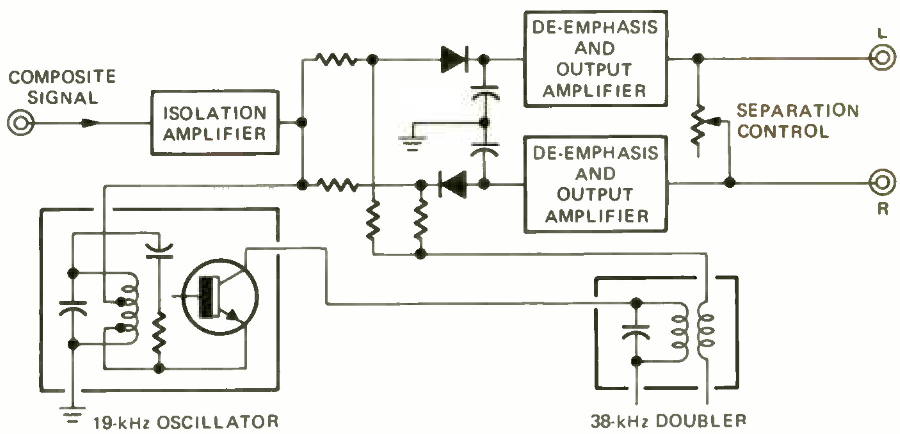
A phase-locked loop is basically a feedback circuit which consists of a phase comparator, a low-pass filter and an error amplifier in the forward signal path and a voltage-controlled oscillator (VCO) in the feedback path. A block diagram of the phase-locked loop in its most basic form is shown in Fig. 4. With no signal applied to the system, the error voltage V_E is zero. The vco operates at a set frequency, ω_o, 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 ω_o and the input signal. If the input signal frequency is close enough to ω_o, 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.





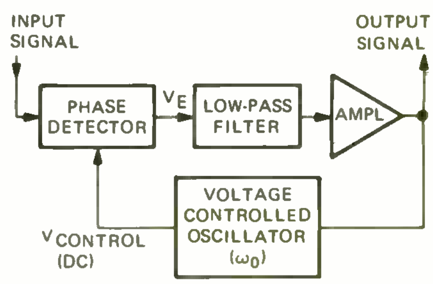


FIG. 2—(top) EARLIEST TYPE of stereo FM decoder suffered from phase shifts because of large number of tuned circuits.

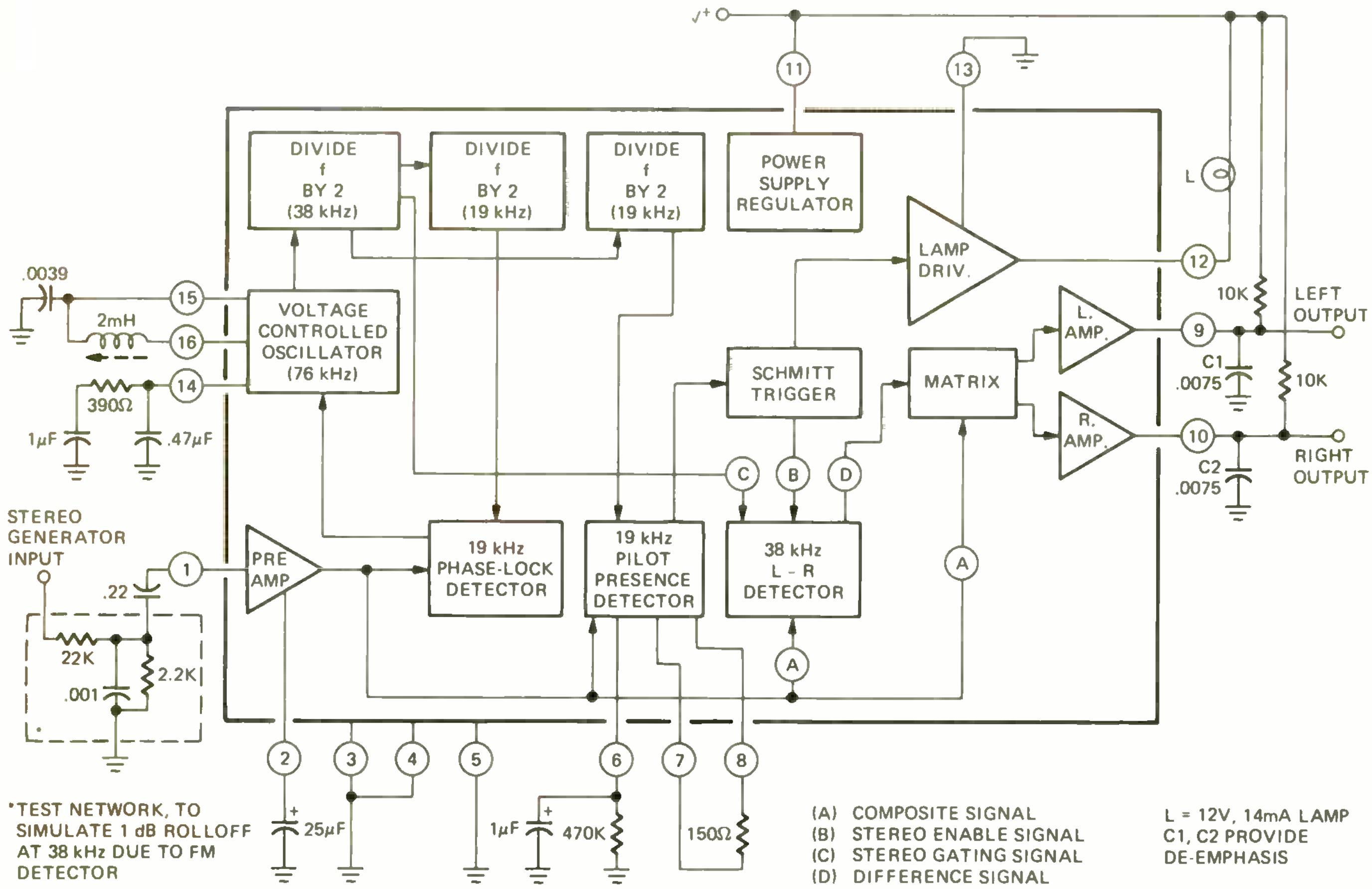
FIG. 3—(above) SWITCHING DECODER has fewer tuned circuits, but is difficult to adjust and drifts.

FIG. 4—(right) SIMPLIFIED BLOCK DIAGRAM illustrates PLL principle.

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



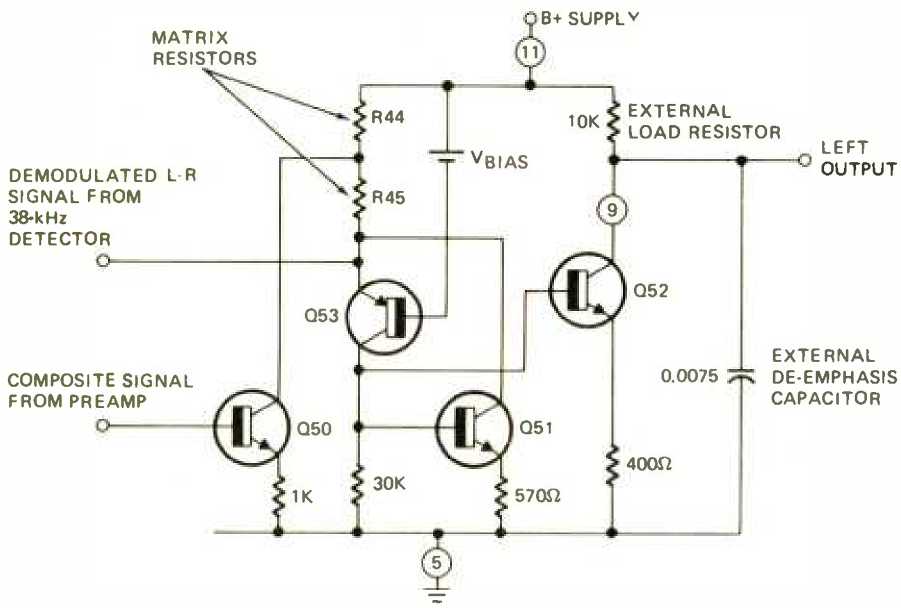


FIG. 5—(above) RCA CA-3090 IC phase-lock-loop system shown in block diagram form.

FIG. 6—(left) PARTIAL SCHEMATIC (left channel only) of matrix-amplifier portion of CA-3090, RCA multiplex decoder IC.

Fig. 6, and the resistor values are chosen to compensate for the fact that most FM detector circuits (the origin of the composite signal from the regular FM tuner) tend to attenuate higher frequencies somewhat because of stray capacitance roll-off and other combined factors. The CA-3090 assumes a 1-dB rolloff at 38 kHz and it is for that reason that the test network shown in Fig. 5 is called for.

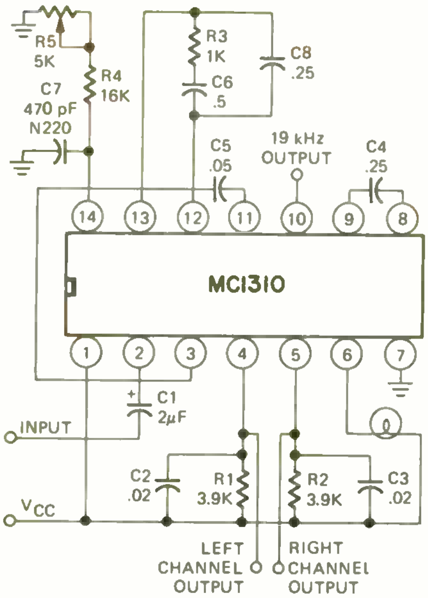
If the composite signal from the tuner detector were "perfect", separation would be reduced to about 26 dB unless deliberate attenuation such as this were introduced between detector output and IC input. Table 1, condensed from RCA's data sheet, summarizes important performance data which may be expected 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.

TABLE 1 – PERFORMANCE DATA, RCA CA-3090Q

SEPARATION		40 dB
DISTORTION	2nd HARMONIC	<0.35%
	3rd HARMONIC	<0.1%
	4th HARMONIC	<0.1%
	5th HARMONIC	<0.1%
CAPTURE (% OF CENTER FREQUENCY)		10%
SCA REJECTION		55 dB
MONAURAL GAIN (75 μSEC DE-EMPHASIS, 1 kHz)		6 dB
GAIN BALANCE BETWEEN CHANNELS		<0.5 dB
STEREO/MONAURAL GAIN BALANCE		<0.5 dB
INPUT IMPEDANCE		50 K
TEMPERATURE COEFFICIENT O LOCAL OSCILLATOR		16 Hz/°C
LAMP DRIVER CURRENT		8 mA

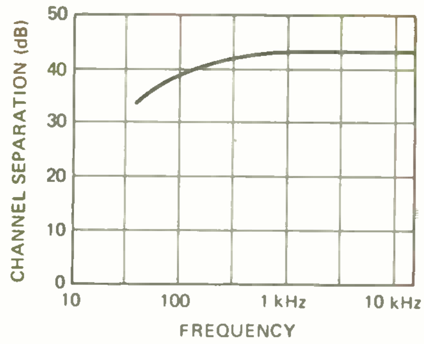
Motorola's inductorless IC

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



PIN FUNCTIONS

PIN 1 = V_{CC}
PIN 2 = INPUT
PIN 3 = AMPLIFIER OUTPUT
PIN 4 = LEFT CHANNEL OUTPUT
PIN 5 = RIGHT CHANNEL OUTPUT
PIN 6 = LAMP INDICATOR
PIN 7 = GROUND
PIN 8 = SWITCH FILTER
PIN 9 = SWITCH FILTER
PIN 10 = 19 kHz OUTPUT
PIN 11 = MODULATOR INPUT
PIN 12 = LOOP FILTER
PIN 13 = LOOP FILTER
PIN 14 = OSCILLATOR RC NETWORK



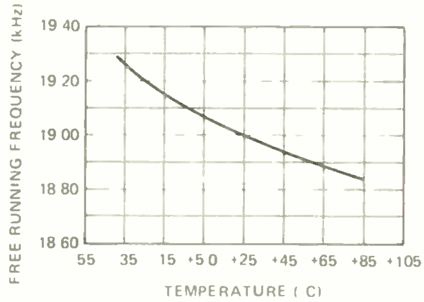


FIG. 7—(top left) HOOKUP of Motorola MC1310 IC as a stereo decoder.

FIG. 8—(top right) CURVE of separation vs frequency for MC1310.

FIG. 9—(below) MOTOROLA IC in block diagram form.

FIG. 10—(above) VCO DRIFT in Motorola MC-1310.

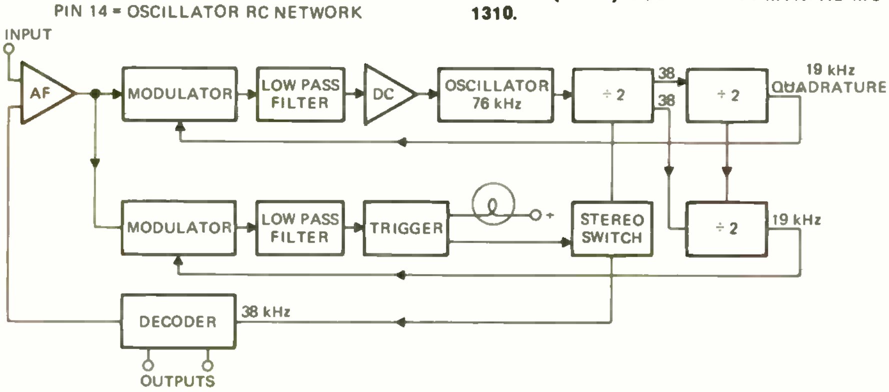


TABLE II

ELECTRICAL PERFORMANCE CHARACTERISTICS, MOTOROLA MC1310P

CHARACTERISTIC	TYPICAL VALUE
Max. Stereo Composite Signal for 0.5% THD	2.8 volts, peak-to-peak
Input Impedance	50,000 ohms
Stereo Separation (50Hz-15kHz)	40 dB
Audio Output Voltage	.485 V, rms
Mono Channel Balance	within 1.5 dB
Total Harmonic Distortion	0.3%
19 kHz Rejection	34.4 dB
38 kHz Rejection	45 dB
Inherent SCA Rejection	80 dB
19-kHz Stereo Switch level	16 mV
Capture Range Of VCO	±3.0%
Operating Supply Voltage Range	8.0 to 16 Vdc

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—Mallory 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

SPR—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 covered in 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.

	ARCH	GE	ICC	IR	MAL	MOT	RCA	SPR	SYL
2N1202	NA	GE-16	NA	TR-03	NA	NA	SK 3012	NA	ECG 105
2N1203	NA	GE-4	NA	TR-03	NA	NA	SK 3012	NA	ECG 105
2N1204	RS276-2004	GE-51	ICC-253	TR-12	NA	HEP-253	SK 3006	NA	ECG 126
2N1205	RS276-2009	GE-60	ICC-53	NA	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1206	NA	GE-63	NA	TR-25	PTC117	HEP-243	NA	NA	NA
2N1207	NA	GE-27	NA	IRTR-78	PTC 117	HEP-713	SK 3045	RT-110	ECG 154
2N1208	NA	NA	NA	NA	NA	HEP-S5001	NA	NA	NA
2N1209	NA	NA	NA	NA	NA	HEP-S5001	NA	NA	NA
2N1210	NA	NA	NA	NA	NA	HEP-S5001	NA	NA	NA
2N1211	NA	NA	NA	NA	NA	HEP-S5004	NA	NA	NA
2N1212	NA	NA	NA	NA	NA	HEP-S5001	NA	NA	NA
2N1213	RS276-2005	GE-2	ICC-2	TR-06	PTC 102	HEP-2	SK3006	NA	ECG 126
2N1214	RS276-2005	GE-2	ICC-2	TR-06	PTC 102	HEP-2	SK 3006	NA	ECG 126
2N1215	RS276-2005	GE-2	ICC-2	TR-06	PTC 102	HEP-2	SK 3006	NA	ECG 126
2N1216	RS276-2005	GE-2	ICC-2	TR-06	PTC 102	HEP-2	SK 3006	NA	ECG 126
2N1217	RS276-2001	GE-5	ICC-641	TR-08	PTC 108	HEP-641	SK 3010	RT-122	ECG 103
2N1218	RS276-2004	NA	ICC-243	TR-01	NA	NA	SK 3009	RT-127	ECG 121
2N1219	RS276-2021	GE-21	ICC-51	TR-19	PTC 131	HEP-51	SK 3114	RT-115	ECG 159
2N1220	RS276-2021	GE-21	ICC-51	TR-19	PTC 131	HEP-51	SK 3114	RT-115	ECG 159
2N1221	RS276-2021	GE-21	ICC-51	TR-19	PTC 131	HEP-51	SK 3114	RT-115	ECG 159
2N1222	RS276-2021	GE-21	ICC-51	TR-19	PTC 131	HEP-51	SK 3114	RT-115	ECG 159
2N1223	RS276-2021	GE-21	ICC-51	TR-19	PTC 131	HEP-51	SK 3114	RT-115	ECG 159
2N1224	RS276-2005	GE-9	ICC-638	IRTR-89	PTC 107	HEP-638	SK 3007	NA	ECG 126
2N1225	RS276-2003	GE-9	ICC-639	IRTR-89	PTC 107	HEP-639	SK 3006	NA	ECG 126
2N1226	RS276-2003	GE-9	ICC-639	IRTR-89	PTC 107	HEP-639	SK 3008	NA	ECG 126
2N1227	RS276-2006	GE-16	ICC-230/232	TR-01	PTC 114	HEP-230/232	SK 3009	RT-124	ECG 104
2N1228	RS276-2021	GE-22	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1229	RS276-2021	GE-22	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1230	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1231	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1232	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1233	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1234	NA	NA	NA	IRTR-88	PTC 141	NA	SK 3025	RT-115	ECG 129
2N1238	NA	GE-67	NA	TR-28	PTC 131	HEP-739	NA	RT-126	ECG 106
2N1239	NA	GE-67	NA	TR-28	PTC 131	HEP-739	NA	RT-126	ECG 106
2N1240	NA	GE-67	NA	TR-28	PTC 131	HEP-739	NA	RT-126	ECG 106
2N1241	NA	GE-67	NA	TR-28	PTC 131	HEP-739	NA	RT-126	ECG 106
2N1242	NA	GE-67	NA	TR-28	NA	HEP-708	NA	NA	NA
2N1243	NA	GE-67	NA	TR-28	NA	HEP-708	NA	NA	NA
2N1245	RS276-2006	GE-3	ICC-230	TR-01	PTC 114	HEP-230	SK 3009	RT-124	ECG 104
2N1246	RS276-2006	GE-3	ICC-230	TR-01	PTC 114	HEP-230	SK 3009	RT-124	ECG 104
2N1247	RS276-2009	GE-11	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1248	RS276-2009	GE-11	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1249	RS276-2009	GE-11	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1250	NA	NA	NA	NA	NA	HEP-S5001	NA	NA	NA
2N1251	RS276-2002	GE-5	ICC-641	TR-08	PTC 134	HEP-641	SK 3010	RT-122	ECG 103A
2N1252	RS276-2009	GE-18	ICC-53	IRTR-87	PTC 125	HEP-53	SK 3024	RT-114	ECG 128
2N1253	RS276-2009	GE-18	ICC-53	IRTR-87	PTC 125	HEP-53	SK 3024	RT-114	ECG 128
2N1254	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1255	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1256	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1257	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1258	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1259	RS276-2021	GE-21	ICC-51	IRTR-88	PTC 103	HEP-51	SK 3025	RT-115	ECG 129
2N1261	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105

	ARCH	GE	ICC	IR	MAL	MOT	RCA	SPR	SYL
2N1262	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N1263	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N1264	RS276-2004	GE-51	ICC-253	IRTR-85	PTC 107	HEP-253	SK 3006	RT-118	ECG 100
2N1265	RS276-2005	GE-52	ICC-254	IRTR-85	PTC 109	HEP-254	SK 3003	RT-120	ECG 102
2N1266	RS276-2005	GE-50	ICC-254	IRTR-85	PTC 107	HEP-254	SK 3005	RT-121	ECG 102A
2N1267	NA	GE-62	NA	TR-21	PTC 121	HEP-50	SK 3124	RT-100	ECG 123
2N1268	NA	GE-62	NA	TR-21	PTC 121	HEP-50	NA	NA	NA
2N1269	NA	GE-62	NA	TR-21	PTC 121	HEP-50	NA	NA	NA
2N1270	NA	GE-62	NA	TR-21	PTC 121	HEP-50	NA	NA	NA
2N1271	NA	GE-62	NA	TR-21	PTC 121	HEP-50	NA	NA	NA
2N1272	NA	GE-62	NA	TR-21	PTC 121	HEP-50	NA	NA	NA
2N1273	RS276-2004	GE-52	ICC-253	IRTR-85	PTC 109	HEP-253	SK 3004	RT-120	ECG 102
2N1274	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 109	HEP-253	SK 3004	RT-120	ECG 102
2N1275	NA	GE-21	NA	IRTR-88	PTC 127	NA	SK 3025	RT-115	ECG 129
2N1276	RS276-2009	GE-60	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1277	RS276-2009	GE-60	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1278	RS276-2009	GE-60	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-100	ECG 123
2N1279	RS276-2009	GE-61	ICC-53	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1280	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1281	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1282	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 107	HEP-2	SK 3005	RT-118	ECG 160
2N1284	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1285	RS276-2003	GE-51	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3006	NA	ECG 160
2N1287	RS276-2004	GE-52	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1288	RS276-2002	GE-7	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1289	RS276-2002	GE-5	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1290	NA	NA	NA	IRTR-85	PTC 102	NA	NA	NA	NA
2N1291	RS276-2006	GE-3	ICC-230	TR-01	PTC 114	HEP-230	SK 3009	RT-124	ECG 104
2N1292	RS276-2006	GE-3	ICC-230	TR-01	PTC 105	NA	SK 3009	RT-127	ECG 121
2N1293	RS276-2006	GE-16	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1294	RS276-2006	GE-16	ICC-232	TR-01	PTC 138	NA	SK 3014	RT-127	ECG 121
2N1295	RS276-2006	GE-16	ICC-232	TR-01	PTC 138	HEP-232	SK 3009	RT-127	ECG 121
2N1296	RS276-2006	GE-3	ICC-232	TR-01	PTC 138	NA	SK 3014	RT-127	ECG 121
2N1297	RS276-2006	GE-16	ICC-232	TR-01	PTC 138	HEP-232	SK 3009	RT-127	ECG 121
2N1298	NA	GE-54	NA	NA	NA	NA	NA	NA	NA
2N1299	RS276-2001	GE-6	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1300	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	NA	ECG 160
2N1301	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	NA	ECG 160
2N1302	RS276-2001	GE-8	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1303	RS276-2007	GE-1	ICC-629	IRTR-85	PTC 102	HEP-629	SK 3004	NA	ECG 158
2N1304	RS276-2001	GE-8	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1305	RS276-2007	GE-1	ICC-629	IRTR-85	PTC 102	HEP-629	SK 3123	NA	ECG 158
2N1306	RS276-2001	GE-5	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1307	RS276-2007	GE-1	ICC-629	IRTR-85	NA	HEP-629	SK 3123	NA	ECG 158
2N1308	RS276-2002	GE-5	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1309	RS276-2007	GE-1	ICC-629	IRTR-85	PTC 107	HEP-629	SK 3123	RT-118	ECG 100
2N1310	NA	GE-5	NA	TR-08	PTC 108	NA	SK 3011	RT-119	ECG 101
2N1311	NA	GE-5	NA	TR-08	PTC 108	NA	SK 3011	RT-119	ECG 101
2N1312	NA	GE-7	NA	TR-08	PTC 108	NA	SK 3010	RT-122	ECG 103
2N1313	RS276-2005	GE-1	ICC-254	IRTR-89	PTC 135	HEP-254	SK 3008	NA	ECG 126
2N1314	RS276-2006	GE-16	ICC-230	TR-01	PTC 105	HEP-230	SK 3009	RT-124	ECG 104
2N1315	NA	GE-3	NA	TR-01B	NA	NA	SK 3123	NA	NA
2N1316	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100
2N1317	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100
2N1318	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100

NA = NOT AVAILABLE

	ARCH	GE	ICC	IR	MAL	MOT	RCA	SPR	SYL
2N1319	RS276-2004	GE-1	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3005	RT-118	ECG 100
2N1330	NA	NA	NA	TR-21	NA	NA	SK 3124	NA	NA
2N1335	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1336	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1337	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1338	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	RT-100	ECG 123
2N1339	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1340	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1341	NA	GE-18	NA	IRTR-87	NA	PTC 144	NA	NA	NA
2N1342	NA	NA	NA	NA	NA	PTC 144	NA	NA	NA
2N1343	RS276-2004	GE-1	ICC-253	IRTR-85	NA	PTC 102	SK 3005	RT-118	ECG 100
2N1344	RS276-2005	GE-1	ICC-254	IRTR-85	NA	PTC 102	SK 3005	RT-118	ECG 100
2N1345	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100
2N1346	RS276-2005	GE-1	ICC-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100
2N1347	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 109	HEP-254	SK 3005	RT-118	ECG 100
2N1348	RS276-2005	GE-2	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1349	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1350	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1351	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1352	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 109	HEP-254	SK 3003	RT-120	ECG 102
2N1353	RS276-2005	GE-2	ICC-254	IRTR-85	PTC 135	HEP-254	SK 3003	RT-120	ECG 102
2N1354	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1355	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1356	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3006	RT-118	ECG 100
2N1357	RS276-2005	GE-1	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1358	NA	GE-4	ICC-233	TR-03	PTC 106	HEP-233	SK 3012	NA	ECG 105
2N1359	RS276-2006	NA	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1360	RS276-2006	NA	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1361	RS276-2004	GE-2	ICC-250	TR-01	PTC 102	HEP-250	SK 3009	RT-118	ECG 100
2N1362	RS276-2006	GE-16	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1363	RS276-2006	GE-4	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1364	RS276-2006	GE-16	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1365	RS276-2006	GE-16	ICC-232	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N1366	RS276-2001	GE-5	ICC-641	TR-08	PTC 107	HEP-641	SK 3011	RT-119	ECG 101
2N1367	RS276-2001	GE-5	ICC-641	TR-08	PTC 107	HEP-641	SK 3011	RT-119	ECG 101
2N1370	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 109	HEP-253	SK 3004	RT-120	ECG 102
2N1371	RS276-2004	GE-2	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1372	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N1373	RS276-2004	GE-2	NA	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1374	RS276-2003	GE-53	ICC-633	IRTR-85	PTC 135	HEP-633	SK 3004	RT-120	ECG 102
2N1375	RS276-2004	GE-2	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1376	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 135	HEP-254	SK 3004	RT-120	ECG 102
2N1377	RS276-2005	GE-2	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1378	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1379	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1380	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N1381	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N1382	RS276-2004	GE-2	ICC-253	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N1383	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1384	NA	GE-9	ICC-2	IRTR-89	PTC 107	HEP-2	SK 3008	NA	ECG 126
2N1385	NA	GE-9	ICC-2	IRTR-89	PTC 107	HEP-2	NA	NA	ECG 160
2N1386	RS276-2009	GE-61	ICC-53	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1387	RS276-2009	GE-61	ICC-53	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1388	RS276-2009	GE-61	ICC-53	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1389	RS276-2009	GE-61	ICC-53	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1390	NA	GE-18	NA	IRTR-87	PTC 139	HEP-50	NA	NA	NA
2N1391	RS276-2002	GE-60	ICC-641	TR-08	PTC 132	HEP-641	NA	RT-122	ECG 103
2N1392	NA	GE-52	NA	IRTR-85	PTC 102	NA	SK 3004	RT-120	ECG 102
2N1393	NA	GE-1	NA	IRTR-85	PTC 102	NA	SK 3005	RT-118	ECG 100
2N1394	NA	GE-51	NA	IRTR-89	PTC 107	NA	NA	NA	NA
2N1395	RS276-2003	GE-9	ICC-3	IRTR-85	PTC 107	HEP-3	SK 3006	RT-118	ECG 100
2N1396	RS276-2003	GE-51	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3006	NA	ECG 126
2N1397	RS276-2003	GE-9	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3006	NA	ECG 126
2N1398	NA	GE-51	NA	IRTR-89	PTC 107	NA	SK 3006	NA	ECG 126
2N1399	NA	GE-51	NA	IRTR-89	PTC 107	NA	SK 3006	NA	ECG 126
2N1400	NA	GE-51	NA	IRTR-89	PTC 107	NA	SK 3006	NA	ECG 126
2N1401	NA	GE-51	NA	IRTR-89	PTC 107	NA	SK 3006	NA	ECG 126
2N1402	NA	GE-51	NA	IRTR-89	PTC 107	NA	SK 3006	NA	ECG 126
2N1403	NA	GE-2	ICC-2	IRTR-89	PTC 102	HEP-2	SK 3123	NA	ECG 160
2N1404	RS276-2005	GE-2	ICC-254	IRTR-85	PTC 102	HEP-254	NA	RT-120	ECG 102
2N1405	RS276-2005	GE-50	ICC-3	IRTR-89	PTC 107	HEP-3	NA	NA	ECG 160
2N1406	RS276-2003	GE-50	ICC-3	IRTR-89	PTC 107	HEP-3	NA	NA	ECG 160
2N1407	RS276-2003	GE-50	ICC-3	IRTR-89	PTC 107	HEP-3	NA	NA	ECG 160
2N1408	NA	GE-2	ICC-2	IRTR-89	PTC 107	HEP-2	NA	NA	ECG 160
2N1409	NA	GE-18	ICC-2	IRTR-89	PTC 125	HEP-2	NA	NA	ECG 160
2N1410	NA	GE-18	ICC-2	IRTR-89	PTC 125	HEP-2	NA	NA	ECG 160
2N1411	RS276-2003	GE-9	ICC-3	IRTR-89	PTC 107	HEP-3	NA	NA	ECG 160
2N1412	NA	GE-4	ICC-233	TR-03	PTC 106	HEP-233	NA	NA	ECG 105
2N1413	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1414	RS276-2004	GE-53	ICC-253	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N1415	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1416	RS276-2005	GE-53	ICC-254	IRTR-85	PTC 135	HEP-254	NA	RT-121	ECG 102A
2N1417	RS276-2009	GE-61	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-102	ECG 123A
2N1418	RS276-2009	GE-61	ICC-53	TR-21	PTC 132	HEP-53	SK 3124	RT-102	ECG 123A
2N1419	RS276-2006	GE-3	ICC-232	TR-01	PTC 114	HEP-232	SK 3009	RT-124	ECG 104
2N1420	RS276-2009	GE-63	ICC-53	TR-21	PTC 125	HEP-53	NA	RT-102	ECG 123A
2N1421	NA	NA	NA	NA	NA	HEP-S5003	NA	NA	NA
2N1422	NA	NA	NA	IRTR-90	PTC 119	HEP-S5003	NA	RT-131	ECG 130
2N1423	NA	NA	NA	IRTR-90	PTC 119	HEP-S5003	NA	RT-131	ECG 130
2N1424	NA	NA	NA	NA	NA	HEP-S5003	NA	NA	NA
2N1425	RS276-2003	GE-50	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3008	NA	ECG 126
2N1426	RS276-2003	GE-50	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3008	NA	ECG 126
2N1427	RS276-2003	GE-2	ICC-3	IRTR-89	PTC 107	HEP-3	SK 3003	NA	ECG 126
2N1428	RS276-2021	NA	ICC-51	TR-19	PTC 127	HEP-51	SK 3114	RT-115	ECG 159
2N1429	RS276-2021	GE-9	ICC-51	IRTR-88	PTC 121	HEP-51	SK 3025	RT-115	ECG 129
2N1430	RS276-2006	GE-16	ICC-232	TR-01	PTC 105	HEP-232	SK 3014	RT-127	ECG 121
2N1431	RS276-2001	GE-59	ICC-641	TR-08	PTC 134	HEP-641	SK 3010	RT-122	ECG 103A
2N1432	RS276-2003	GE-9	ICC-3	IRTR-85	PTC 102	HEP-3	SK 3004	RT-120	ECG 102
2N1433	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N1434	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N1435	NA	GE-4	NA	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N1436	NA	GE-50	ICC-2	IRTR-89	PTC 107	HEP-2	NA	NA	ECG 160
2N1437	NA	GE-3	NA	TR-01B	PTC 138	NA	NA	NA	NA
2N1438	NA	GE-3	NA	TR-01B	PTC 138	NA	NA	NA	NA
2N1439	RS276-2021	GE-21	ICC-51	TR-28	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1440	RS276-2021	GE-21	ICC-51	TR-28	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1441	RS276-2021	GE-21	ICC-51	TR-28	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1442	RS276-2021	GE-21	ICC-51	TR-28	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1443	RS276-2021	GE-21	ICC-51	TR-28	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1444	NA	GE-63	NA	TR-25	PTC 144	HEP-S3011	NA	NA	NA

NA = NOT AVAILABLE

(continued next month)

R-E's Service Clinic

trapping the creeper

A case of grid emission at its worst

JACK DARR
SERVICE EDITOR

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

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

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.

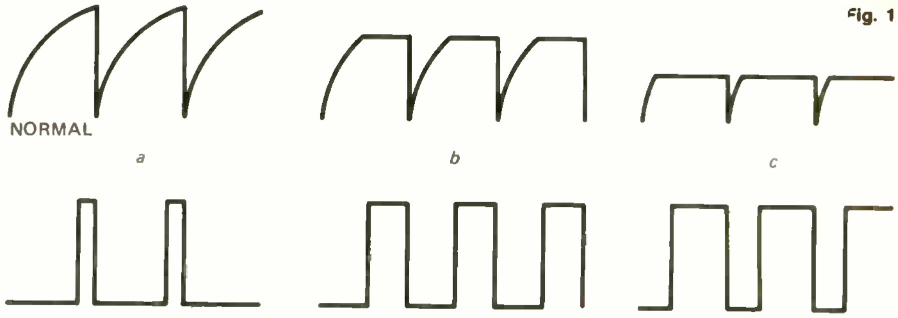
Another handy-dandy cause for this is the grid-bias control type of high-voltage hold-down circuit. These things use a pulse from the flyback, fed into a diode in the horizontal output tube's grid return circuit. When the output goes up, the pulse amplitude increases. This is rectified, and converted 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 symtoms. 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



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 6JE6. Since then, I've seen it in 6LQ6's, 31LZ6's and so on. So, if you find a creeper, scope the horizontal output tube grid, with the current-meter 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**

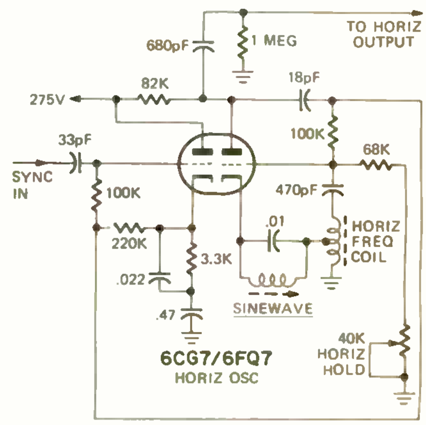
reader questions

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-CWD, 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 possibiles 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 would 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 desoldering 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 Molex, 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 bad, the agc 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

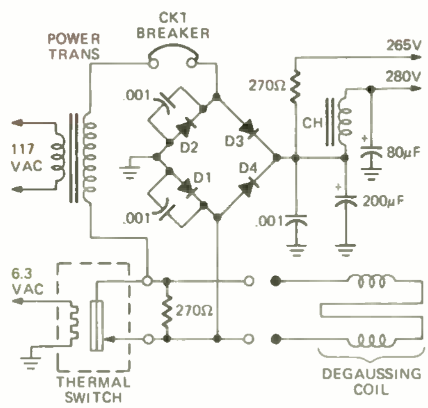
I can get an i.f. signal through from the input, and see good clear bars on the screen. No stations from the antenna. I suspect the tuner. Right?—R.B.M., Miami, Fla.

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 5H10 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 extracted from the incoming signal!)

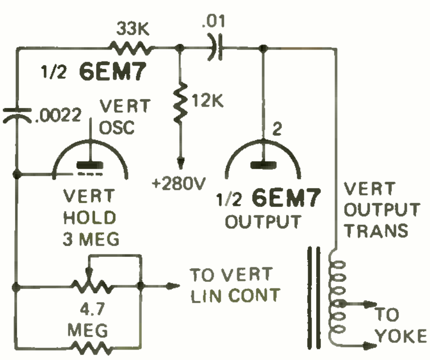
When you turn the horizontal hold control, you "move" this pulse. In effect, you change the *phase* with respect to the horizontal sync from the signal. So you shift the acc; you may clip off part of the color-burst, and so on. Horizontal hold control on these sets must be adjusted exactly in the middle 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 558. 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., Blauvelt, 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 6GH8 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 afc, and make the picture hold normally; horizontal hold very sharp, of course.

The waveform from the pulse winding to afc and 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 6BK4, 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.)

HOT (NEW) FLYBACK

This Admiral L33L31 came in with a burnt flyback. I replaced it with a new (bleep) exact duplicate. First replace-

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 I^2R 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 50HK6 output tube burns out about every two months. In the shop, everything 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.

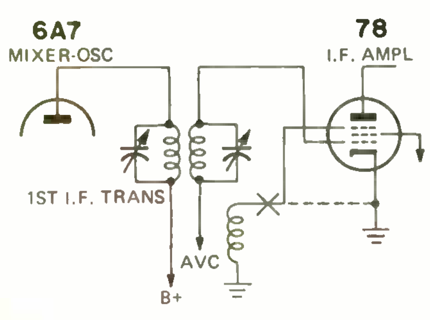
If this is it, you can add a small line-ballast resistor, to hold the voltage down to about 105 for best tube-life. Check this in the shop with a Variac, and be sure that the resistor is well-protected; it'll get pretty hot.

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 network, 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!

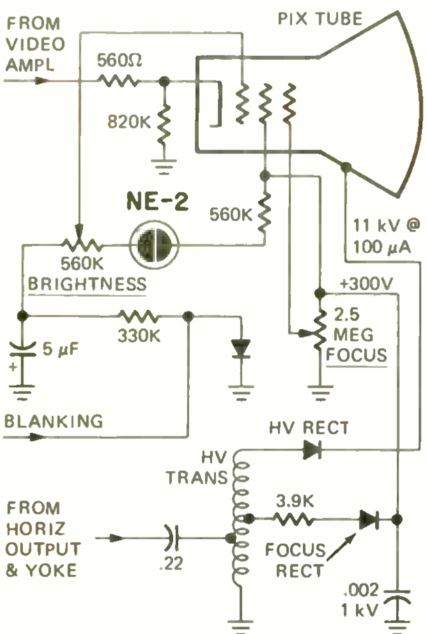
Thanks to Ray Musick, Ballwin, Mo., for this oddball.

HV RECTIFIER HOT

This Electrohome V2-902 Video

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 ultor 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 possibles 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 vtvm or vom 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 T924 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.I., Brooklyn, N.Y.

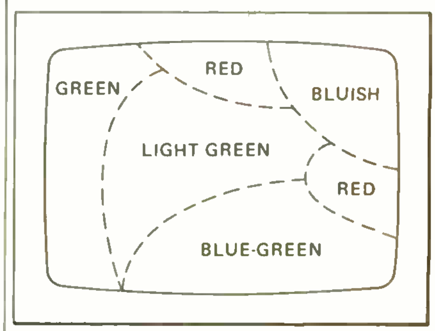
The most likely cause is picture tube *bias*. Check the voltages between grids and cathodes; this is actually what determines beam current. If the grids are too far negative or cathodes too far positive (same thing), you won't be able to get enough beam current. Check the screens of the picture tube,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

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.

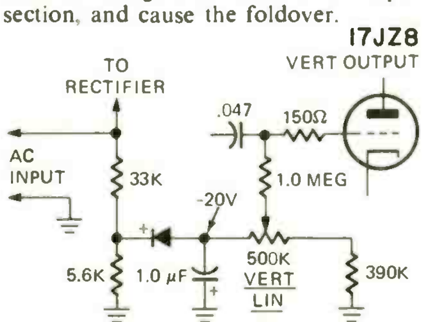
Check the two integrators in this circuit; these are the little "three-legged" types, looking like dual ceramic capacitors. I doubt if they'll be shorted, but you may find the one in the feedback loop has increased in resistance, or is intermittently opening up. Normal resistance should be about 87,000 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 foldover 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 17JZ8 output section, and cause the foldover.

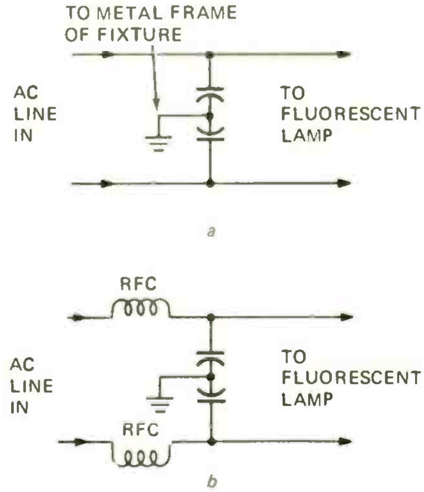


FALSE TRIGGERING OF BURGLAR ALARM

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.

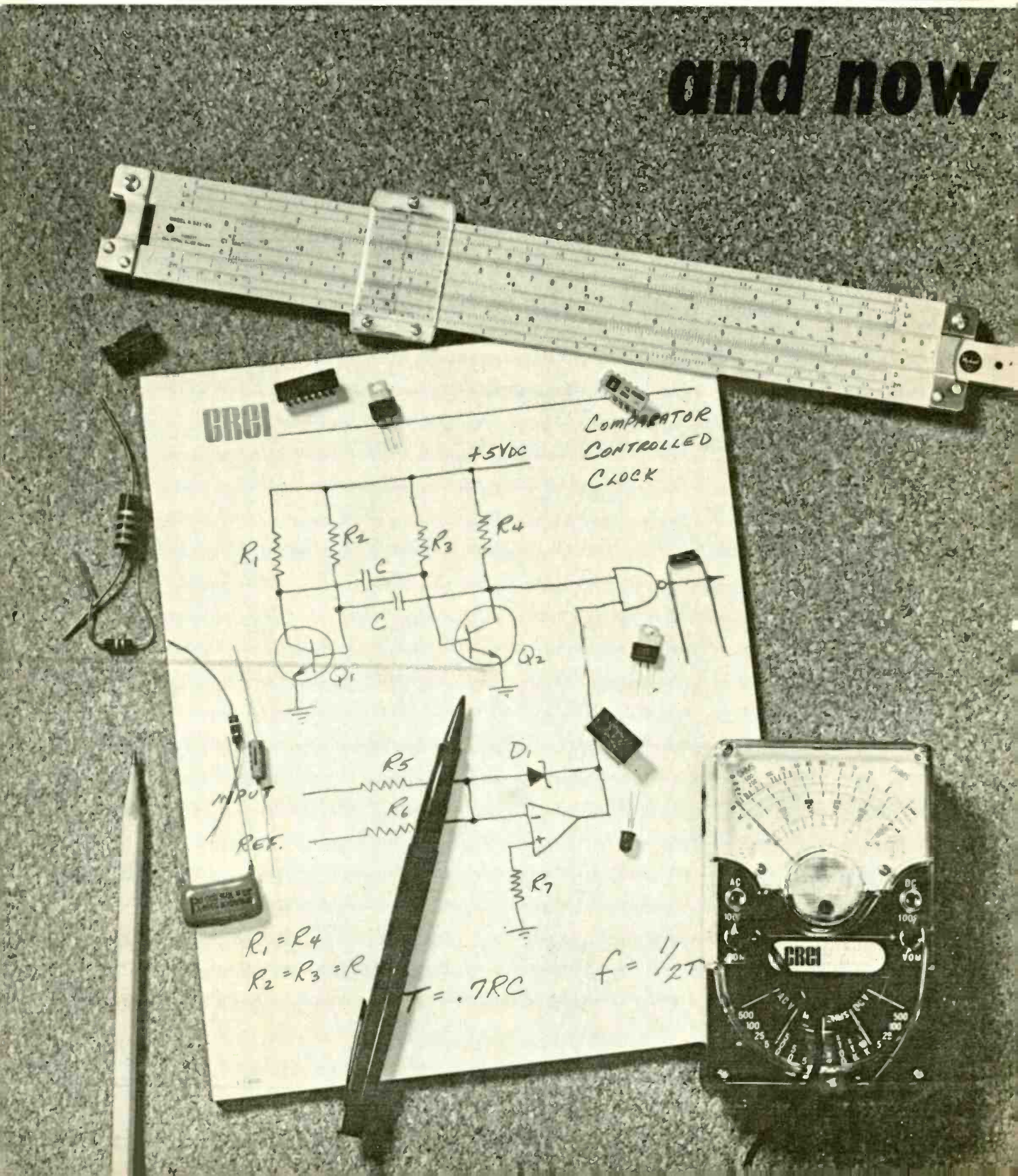
It sounds as if your alarm wiring is picking up some of the "rfi" or radio-frequency hash generated by some older fluorescent lamps. They can cause quite a lot, if unfiltered.

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**

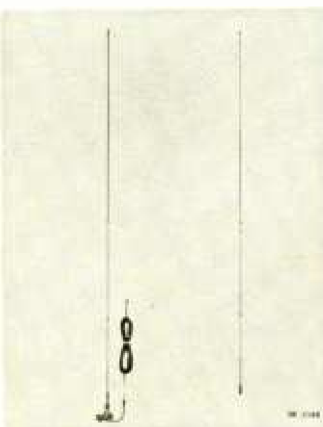
CREI—the <u>only</u> home-study college-level training



new products

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.

TWO-METER MOBILE ANTENNA, *model CGT-144* has low radiation angle and 5.2 dB gain over a ¼-wave ground plane. Complete system includes collinear antenna with stainless steel radiating sections, 180° swivel ball, heavy-duty trunk lip mount for "no holes" installation on



side or edge of trunk lip and 17′ Mil Spec RG-58-U coax with factory attached connectors.

Power rated at 200 watts FM, it has a SWR of 1:1:1 (typical) at resonance and within 1:5:1 over its 6MHz bandwidth of 143-149 MHz. Overall length is 86″. 84″ collinear antenna with ⅜″ -24 threaded base fits standard mobile ball mounts.—**New-Tronics Corp.,** 15800 Commerce Park Drive, Brook Park, Ohio 44142.

Circle 31 on reader service card

TRIGGERED OSCILLOSCOPE, *model 511* includes active sync separators for viewing TV vertical and horizontal and

field 1 and field 2 VITS. Has horizontal input on the front panel with front panel switch selectable ac/dc coupling for vectorscope operation. No external coupling capacitors are needed. Three snap-in overlays are provided. 10 MHz triggered bandwidth is available with high-frequency sync adjustments. Simplified controls, bright trace, large 8 x 10 cm display area. There is a trace invert switch so signals can be observed even though they go through an inverting amplifier. Regulated power supply for high line/low line operation—105V to 125V, 60 Hz.

8½″ x 10″ x 17″; single channel $395.00, dual channel $495.00.—**Hickok Electrical Instrument Company,** 10514 Dupont Avenue, Cleveland, Ohio 44108.

Circle 32 on reader service card

STEREO SPEAKER SYSTEM KIT, *model SK96RRFX* has two 6″ x 9″ dual-cone speakers with 20 oz. Syntox-6 ceramic magnets. Flexair suspension for improved bass response. Power rating is 25 watts. Extended frequency response is 40-16,000 Hz with resonance of 50 Hz.

Impedance is 8 ohms. Weather resistant. Kit includes custom fit grills, 15′ heavy duty stereo wire, mounting hardware and complete instructions.—**Jensen Sound Laboratories,** 4310 Trans World Road, Schiller Park, Ill. 60176.

Circle 33 on reader service card

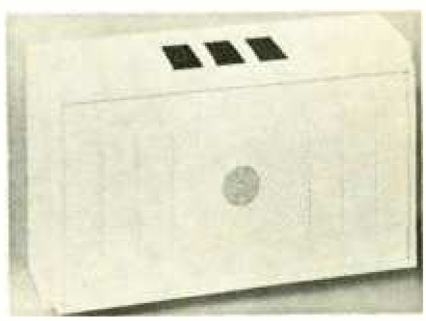
POCKET-SIZE OHM TRACER, *model 4371* has a 0 to 5000-ohm resistance test range with 2% accuracy. Two built-in standards are 20 ohms and 200 ohms. Uses low 0.08 Vdc test voltage for in-circuit testing of solid-state circuitry. There is no danger of creating false signals or damaging components tested. Can also be used as a continuity tester.

No meters to watch as volume con-

trolled audible alarm signals less than calibrated resistance. Circuit is self adjusting to insure accuracy as battery power diminishes. Battery life is 200 hours; fused probe protects tester from misuse and leads are 4 feet long. 3⅞″H x 2½″W x 1⅛″D; 8.5 oz.; $56.00.—**Ecos Electronics Corporation,** 205 West Harrison Street, Oak Park, Ill. 60304.

Circle 34 on reader service card

DISASTER ALARM KIT detects gas or smoke to activate an alarm buzzer. The unit detects natural gas, methane gas,



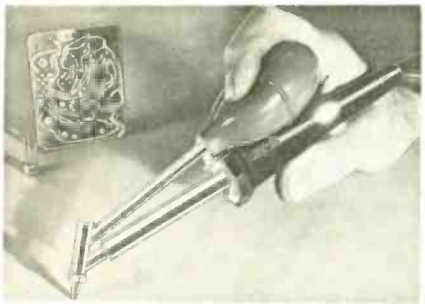
carbon monoxide, iso-butane or any of the ionized gases and smoke in homes, work-shops, garages or any other area where there is a possibility of a dangerous gas leak.

The unit is complete with assembly instructions and a white plastic case. Unit runs on 120 Vac. $19.95.—**Radio Shack,** 2617 West 7th Street, Fort Worth, Tex. 76107.

Circle 35 on reader service card

DESOLDERING IRON PENCIL, *model 510* has safety power indicating light, 3-way on-idle-off switch and supporting bracket to insure proper alignment.

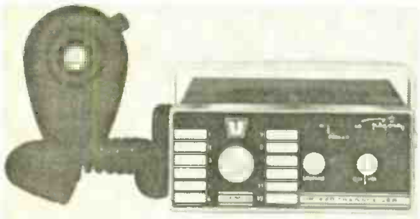
Operates at 40 W and idles at 20 W. Built-in light indicates operation at both heats with a different intensity for each. Unbreakable polycarbonate handle, flexible, burn-resistant neoprene cord and eight tip sizes. 8½″ long; 3½ oz.; $15.95. Converts to dual heat soldering iron with



¼" shank plug type tip.—**Enterprise Development Corp.,** 5127 East 65th Street, Indianapolis, Ind. 46220.

Circle 36 on reader service card

FM TRANSCEIVER, *model HR-220* for amateur communications in the 220 to

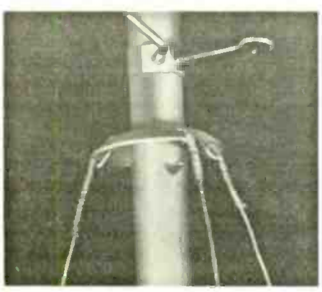


225-MHz range. 12-channel transmitter puts out ten watts minimum from 13.8-V dc power supply with phase modulation and automatic deviation limiting. Each crystal-controlled channel is equipped with individual trimmer capacitor for frequency netting. Built-in VSWR bridge limiting circuit protects the rf power amplifier.

Audio output is five watts. Noise operated squelch system provides clear reception. Sensitivity rated at 0.4-μV (nominal), 20 dB quieting. 2¼" x 5½" x 7½"; $239.00 complete with factory installed transmit and receive crystals for 223.50 MHz. Hand-held, plug-in ceramic mike is included as is dash mounting bracket.—**Regency Electronics Inc.,** 7900 Pendleton Pike, Indianapolis, Ind. 46226.

Circle 37 on reader service card

TELESCOPING ANTENNA MAST is constructed of extra-strength Golden Duratube special process steel and is available in 20, 30, 40 and 50-foot telescoping lengths. Features contoured guy rings that eliminate sharp, wire-fraying edges. This steel is bonded inside

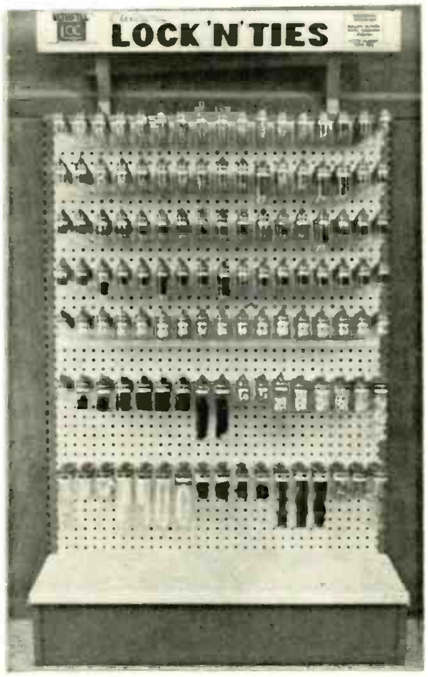


and out with oxide primer and is then overcoated with a tough, golden acrylic finish that resists corrosion. Guy rings are made of aluminum and rest on swaged shoulder of the mast which allows the mast to be firmly guyed before the antenna is oriented.—**Channel Master,** Ellenville, New York.

Circle 38 on reader service card

Circle 16 on reader service card

LOCK'N'TIES consist of cable clamps, ties and solderless terminals. Brand new are the nylon screws, washers and



spacers. 91 different products are packaged in hang-up plastic tubes and have same list price.—**Workman Electronic Products, Inc.,** Box 3828, Sarasota, Fla. 33578.

Circle 39 on reader service card

Circle 17 on reader service card

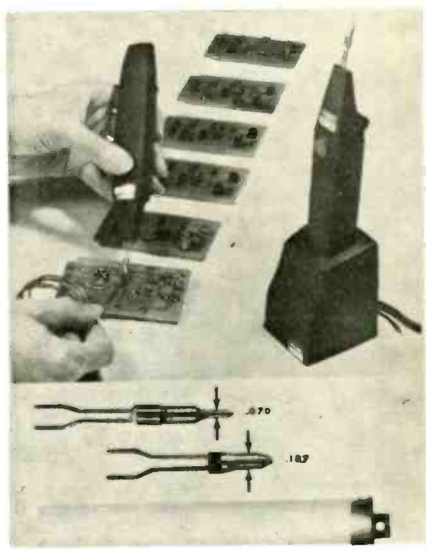
SMALL ENGINE TUNE-UP METER, *CM-1045* is a solid-state tune-up tool for all one to four cylinder, 2- and 4-cycle engines. Tests volts, ohms, dwell, continuity. In many cases permits checking the entire ignition system on a small engine without tearing it down to get at the ignition points behind the flywheel.

Built-in tachometer with snap-on inductive pickup and 0 to 3,000 plus 0 to

15,000 rpm ranges. By connecting the leads, rpm can be read on any engine from one to 4 cylinders without switching for the number of cylinders. Completely portable, powered by three 1.5-V C batteries; self-contained in snap-lock oil-gas-water-resistant case; $39.95.—**Heath Company,** Benton Harbor, Mich. 49022.

Circle 40 on reader service card

CORDLESS SOLDERING IRON, *Iso-Tip.* For use in all types of field repairs, for soldering on water, in air, for repairs to X-Ray and electronic lab equipment and for previously inaccessible areas such as



tower and antenna work and test flights in aircraft where ac power is not available. Quick heating isolated tip design prevents burning of wires near tip. 8"; 6 oz; 5-second heat.—**Wahl Clipper Corp.,** 2902 Locust St., Sterling, Ill. 61081. **R-E**

Circle 41 on reader service card

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 keyboard, semiconductor coolers, heat sinks, transistors, Zener diodes, power transistors, IC's, diode rectifiers, SCR's, semiconductors, transformers, AM/FM stereo multiplex receiver, radiosonde 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 strapping tools, hand unwrapping tools, wrapping tool kit, unwrapping tool kit, manual wire unwrap gun & accessories 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 magna-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 M5V 1K8.

1973 SEMICONDUCTOR CROSS-REFERENCE GUIDE *HMA-07.* Approximately 43,000 semiconductor devices are cross-referenced to HEP 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 assembling data necessary for construction of sound system.—**Dukane Corp.,** 2900 Dukane Drive, St. Charles, Ill. 60174.
R-E

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 in a typical circuit. Troubleshooting procedures previously described also apply here.

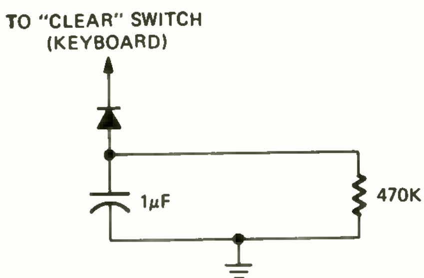


FIG. 8—TYPICAL AUTOMATIC CLEAR CIRCUIT. Clear line is grounded momentarily when power is first applied to the calculator.

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 Intergration) 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

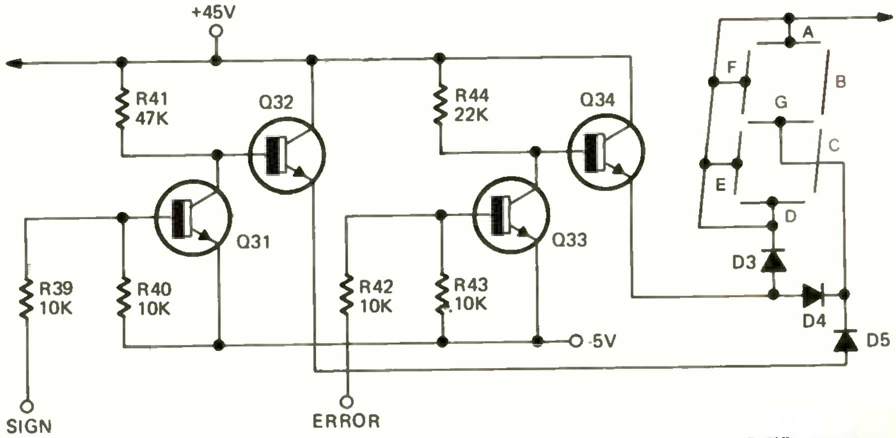


FIG. 9—THE MINUS SIGN is made by forward-biasing D5, lighting indicator segment G. When an error occurs, diodes D3 and D4 are turned on, forming an "E" by lighting segments A, D, E, F and G.

machine is not on) and pry up each side of the IC package with a screwdriver using a gentle rocking motion until it comes loose. When the IC comes free of the socket, pick it up without touching the pins and place the unit on a piece of Styrofoam covered with aluminum foil.

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 chip. 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 **R-E**

Circle 21 on reader service card

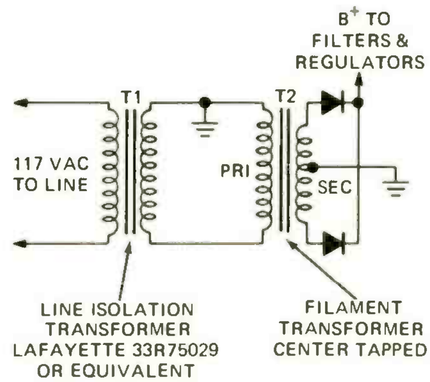
Circle 22 on reader service card

technote

HUM REDUCING METHOD

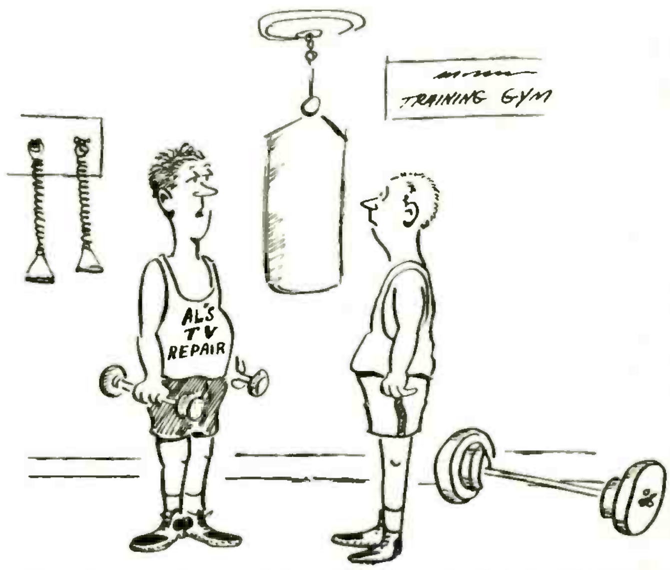
Often, when one builds a high-sensitivity line-operated piece of equipment 60-Hz hum can be a problem. Large filter capacitors and shielded cable help but to reduce 60-Hz hum and line noise to a minimum the special shielding technique described here can be used.

A major source of hum in ac equipment comes from the step-down transformer used to supply the dc voltage. Even if the transformer is mounted away from sensitive circuits it still generates enough of a magnetic field to in-



duce hum. One technique is to use a shielded transformer. However these are not always available, or are too expensive. A better method is to use two transformers, grounding (as shown) one of the common connections, or if available the center tap of one unit. In effect the secondary winding acts as an electrostatic shield grounding out all hum.

Transformer T1 is a 117-to-117 volt isolation transformer. T2 is an ordinary filament transformer whose secondary matches the dc voltage required. With the circuit shown and the unit used hum and line noise in a high-sensitivity audio amplifier was reduced by a factor of 5 over the usual single transformer method.—*Robert Liebman* R-E



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

books

***INTRINSIC SAFETY* by R. J. Redding. McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, N.Y. 10020. 180 pp. $12.50.**

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.

***BASIC ELECTRONIC TEST PROCEDURES* by Irving Gottlieb. Tab Books, Monterey & Pinola Sts., Blue Ridge Summit, Pa. 416 pp. $6.95.**

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 Forest H. Belt. 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.

***TESTS-ANSWERS FOR FCC FIRST AND SECOND CLASS COMMERCIAL LICENSE* by Warren G. Weagant. Command Productions, P.O. Box 26348, San Francisco, Calif. 94126. 69 pp. $9.95.**

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 does take his license examination.

***COLOR TELEVISION THEORY AND SERVICING* by Clyde N. Herrick. Reston Publishing Co., Inc., Box 547, Reston, Va. 22090. 372 pp.**

A completely up-to-date approach that provides sound coverage of solid-state color television receivers, circuitry, operation and troubleshooting. Fully illustrated with line drawings and photographs, some in full color, this book accents 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 i.f. circuitry. The author explains troubleshooting based on picture analysis and instrument troubleshooting.

***TRANSISTOR CIRCUIT DESIGN* by Laurence G. Cowles. Prentice-Hall, Inc., Englewood Cliffs, N.J. 344 pp. $16.00.**

A manual of practical transistor circuit design, this book gives technicians, 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 instrumentation 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 theory is kept to a minimum. Standard electrical components are used. Projects incltde an electroscope, a saltwater voltaic cell, an electrolytic conductivity tester, an electrically heated thermostat, a polarized vane meter, a galvanometer, a repulsion moving iron meter, a moving coil meter and experiments with a moving coil meter. R-E

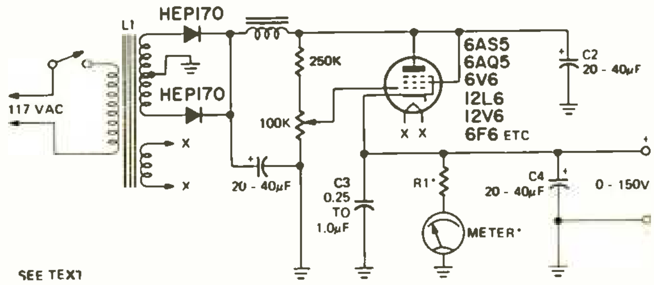
Circle 77 on reader service card

circuits

VARIABLE BATTERY ELIMINATOR

We do industrial work, including metal locators and pipe finders. Occasionally an older type using 1½-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

$150 \times 1_{(volt)}/.005_{(amps)} = 150/.005$ or 30,000 ohms. Similarly, R1 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* **R-E**

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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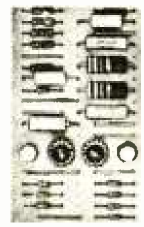

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Circle 26 on reader service card

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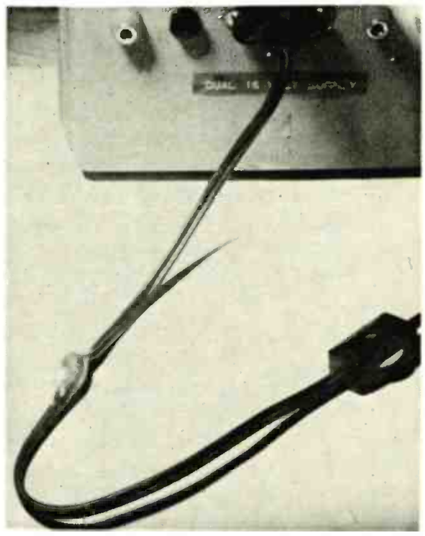
SEPARABLE POWER CORDS

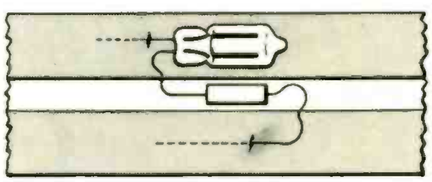
Equipment designed to operate from the power line naturally needs a line cord. Any time its not in actual use, however, the trailing cord can be just a plain nuisance. By modifying a few TV cheater cords you can eliminate the line cord, an indicator light, and on-off switch in each of your future projects. 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*

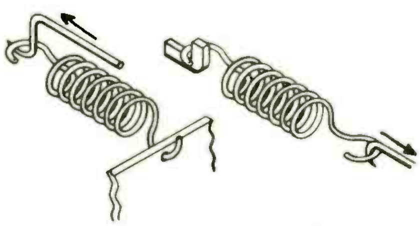
USEFUL SPRING HOOK

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.

a *b*



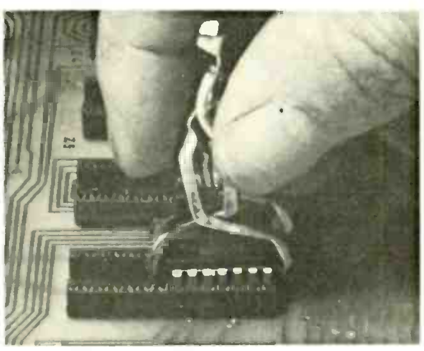
c *d*

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*

R-E

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 incoming 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 circuit 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 tolerated without degrading the performance 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-tunning oscillator frequency. This corresponds to end frequencies of 19,475 Hz and 18,525 Hz—a far cry from the 30-Hz departure from 19-kHz associated with conventional transformer and coil-tuned multiplex decoder circuits. If no regard is given to temperature compensation, free-running frequency 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 consumer use of the tuner or receiver product.

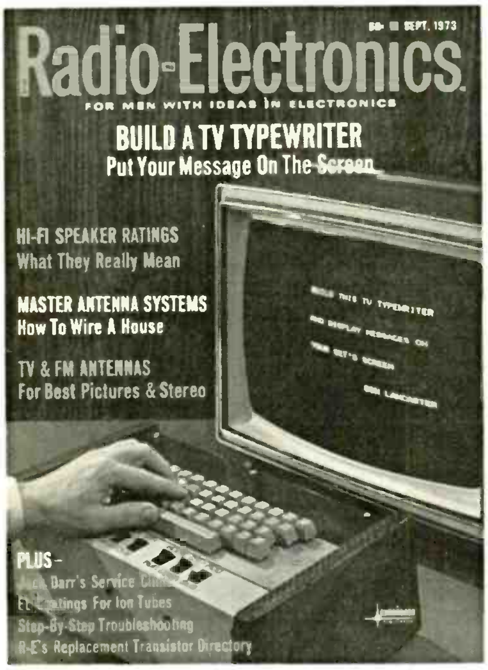
Although the phase-locked loop principle has been known and understood for more than 40 years, its practical use in consumer electronics had to await the development of large-scale integration of circuits into single IC chips which we now take for granted. The Motorola MC1310P contains no less than 58 active transistor elements and three diodes plus a Zener 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 approximately ¾ inch by ¼ inch x 3/16 inch!

Other applications for phase-lock-loop circuitry in high fidelity equipment are being devised in laboratories around the world. As more information becomes available, we shall perhaps devote a future article to other hi-fi applications of the phase-lock-loop circuit. R-E

next month

SEPTEMBER 1973



- **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, leakage 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 magnetron and rf gaskets are not seated properly.

INTERNATIONAL CRYSTAL makes this electronic 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 interlock 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 equipment 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. **R-E**

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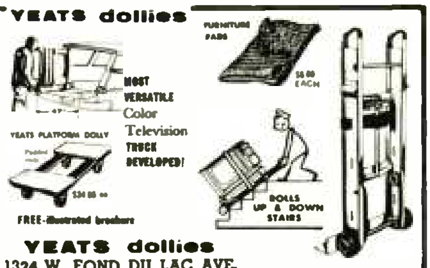

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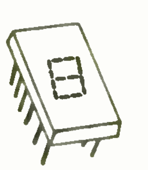

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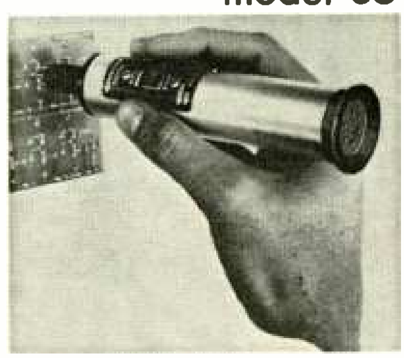

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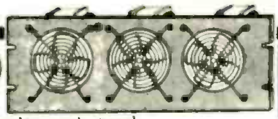
3 "FANS ON A RACK"



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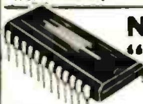

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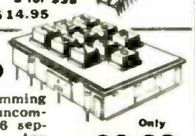

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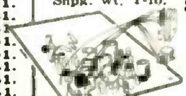

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(A) TO-5 or DIP dual in line pak

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*TO-3 case, — others TO-5

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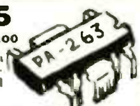
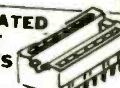


INTEGRATED CIRCUIT SOCKETS



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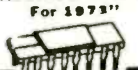

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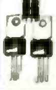

For Class AB use. Basic includes: Signetic 540 30 transistor high power driver TO-5 "IC", with a pair of complimentary 35-watt plastic transistors, i.e. 2N5296 npn and 2N6109 pnp. With schematics, printed circuit and parts board layouts.

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Circle 74 on reader service card

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MARKET CENTER

SCHOOL DIRECTORY

APPLIANCE CLINIC
(continued from page 22)

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 mounted on a 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 gaskets. If you happen to have a tube of Soft Permatex in your garage, it will often make very good gaskets for these little boxes. **R-E**

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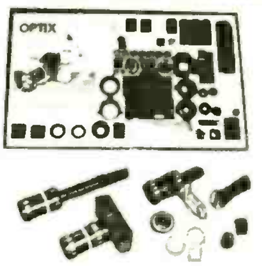

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