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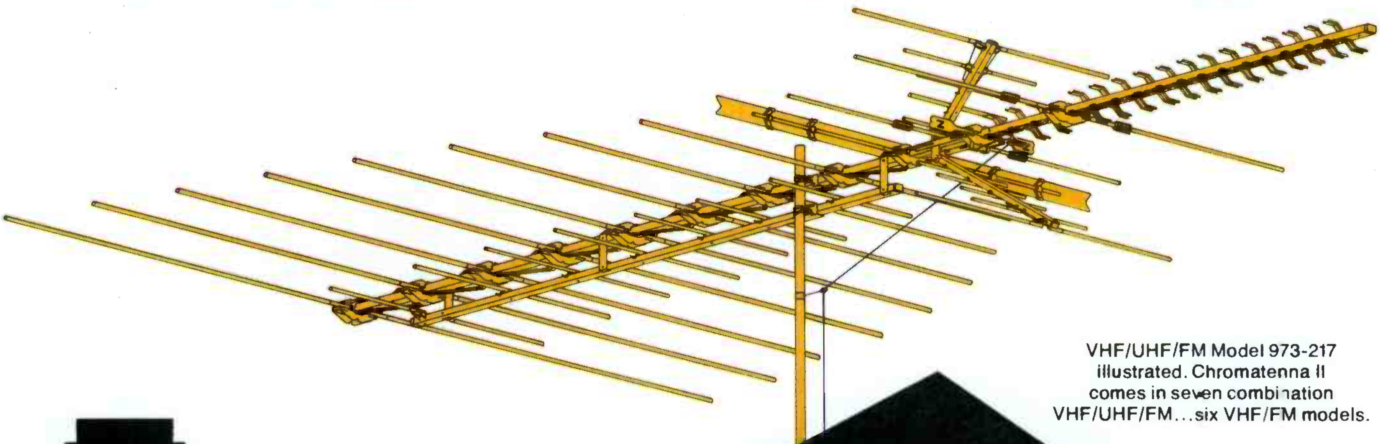
ZENITH

CHROMATENNA II

T.M.



VHF/UHF/FM Model 973-217 illustrated. Chromatenna II comes in seven combination VHF/UHF/FM...six VHF/FM models.

Transmission Line Termination bleeds off static charges thru antenna system ground. Terminal stub improves front to back ratio on lower channels.

Wide-Spaced, Heavy-Duty Feed Lines help prevent shorting from heavy build-ups of snow or ice.

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High-Impact Plastic Insulators double-lock each element to the boom for extra bracing and durability.

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FM Block reduces FM gain up to 12dB. Remove to receive full FM gain.

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Corner Reflector Bracket enlarged and re-located in most models.

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Zenith Dipole on UHF. (Combination models only.)

Electrically Matched Terminals With Stainless Steel Screws eliminate mismatch... protect against rusting, and provide positive electrical contact with improved no-strip stainless steel serrated washers for the take off terminals.

VHF Colinear Directors provide extra signal boost on both low and high band VHF.

Proximity Spaced Signal Balancer (Z elements) provides automatic taper control of periodic driver, improves impedance matching and signal leveling on both Lo and High band channels. Improves Channel 7 pattern.

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The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

July, 1984
Volume 4, No. 7

In a TVRO system, the dish concentrates the satellite signal onto the antenna feedhorn. Selection, installation and orientation are critical. See story on page 12. (Photo courtesy KLM Electronics, Inc.)

Trans-former volts	Trans-former amps	Capaci-tance (mF)	DC voltage swing	Ripple (%)	DC amps
25.2	1.00	1000.	29.0 - 34.9	18.6	0.357
25.2	1.00	2200.	32.2 - 34.9	8.1	0.357
25.2	0.60	1000.	31.4 - 34.9	10.8	0.214
25.2	0.60	2200.	33.3 - 34.9	4.8	0.214
25.2	0.45	470.	29.2 - 34.9	17.8	0.161
25.2	0.45	1000.	32.3 - 34.9	8.0	0.161
25.2	0.45	2200.	33.7 - 34.9	3.5	0.161
25.2	0.20	220.	29.5 - 34.9	16.8	0.071
25.2	0.20	470.	32.4 - 34.9	7.5	0.071
25.2	0.20	1000.	33.7 - 34.9	3.5	0.071
25.2	0.20	2200.	34.4 - 34.9	1.6	0.071
25.2	0.10	100.	29.0 - 34.9	18.6	0.035
25.2	0.10	220.	32.2 - 34.9	8.1	0.035
25.2	0.10	470.	33.7 - 34.9	3.7	0.035
25.2	0.10	1000.	34.3 - 34.9	1.7	0.035
25.2	0.10	2200.	34.7 - 34.9	0.8	0.035
24.0	1.00	1000.	27.3 - 33.2	19.7	0.357
24.0	1.00	2200.	30.5 - 33.2	8.5	0.357
24.0	0.60	1000.	29.7 - 33.2	11.4	0.214
24.0	0.60	2200.	31.6 - 33.2	5.0	0.214
24.0	0.30	470.	29.4 - 33.2	12.1	0.107
24.0	0.30	1000.	31.5 - 33.2	5.5	0.107

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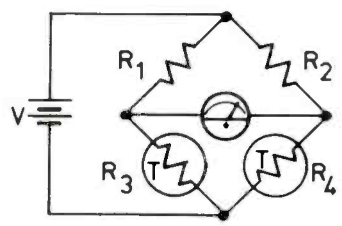

Figure 2

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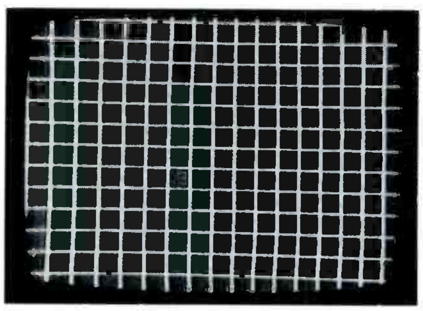
Departments



Next Month...

The ES&T Test Lab features the Sencore model VA62. It is a large state-of-the-art instrument having functions of a phase-locked video generator, an all-channel RF generator, a television signal-injection analyzer with IF and drive signals, a VCR analyzer and a dc and peak-to-peak voltmeter.

So Long, Satcom I

For 8½ years, through the silent cold of space it has been orbiting above the earth. In that time, it has traveled more than one-half billion miles while never straying from its station 23,000 miles above a point on the equator. *Satcom I,* this country's first 24-transponder domestic communications satellite has done its job, lived out its life, and on June 4 was retired. According to a June news release from RCA, the broad communications capacity of Satcom I made possible the growth of cable television into today's multibillion dollar market, and ushered in the era of low-cost, long-distance telephone communications.

Satcom I was thrust into orbit at 8:57 p.m. on Dec. 12, 1975 by Delta 118. Earlier satellites were capable of only 12 communications channels (transponders), but by using a method called cross-polarization and frequency interleaving, Satcom was able to deliver 24 channels. This doubling of capacity permitted lower cost long-distance communications service. Another Satcom feature was 3-axis stabilization which simplifies attitude control compared to "spinner" satellites, and permits more accurate pointing of the satellite.

Cable programming via Satcom I started with *Home Box Office* and *WTBS,* and grew from there. Growth was slow at first, then became more rapid as it became recognized that satellites were the only means by which cable TV signals could be transmitted throughout the US at low cost.

During the eight and a half years it was in synchronous orbit, Satcom was maneuvered remotely from earth to keep it in an assigned position in the orbital arc by firing on-board thrusters. The firing of these small rockets compensated for the downward pull of gravity and the effect of solar winds. These control thrusters are powered by hydrazine fuel. When the fuel is exhausted, the satellite is no longer under the control of earth. Satcom carried an 8-year supply of hydrazine.

The number of satellite positions in the geosynchronous orbit above the equator is limited. When a satellite in synchronous orbit can no longer be controlled, it must be removed from that orbit. On June 4, a control on earth was actuated and a signal was beamed to Satcom I. The last of its hydrazine fuel flowed into the thrusters and the satellite was boosted out of its orbit. The satellite will continue to circle the earth above the equator, but each successive orbit will carry it farther and farther away from the earth. When the pull of gravity is no longer strong enough, Satcom will speed away from earth, possibly to be captured into orbit by some other planet, or to wander endlessly through space, or perhaps to plunge to a fiery end into the sun.

No gold watch, no retirement party, no Social Security: Satcom's retirement was a quiet affair that passed with little fanfare. But the world of communications has been considerably broadened during the eight plus years it spent in orbit. And whether you sell TV equipment, service or install it, or just sit back and watch, Satcom's effect on your television has been profound.

Nils Conrad Persson

ELECTRONIC Servicing & Technology

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Technology

Smaller ICs?

Enhanced-contrast yields closer circuit spacing

Scientists at the *General Electric Research and Development Center,* Schenectady, NY, have invented a practical way to make next-generation microelectronic chips with present-generation processing equipment.

Their basic development is a proprietary *contrast-enhancement* material that is applied to semiconductor wafers at the beginning of the fabrication cycle. This coating extends the capability of making chips with ultra-small circuits.

Aided by the coating, GE researchers have produced experimental microcircuits with linewidths of only 0.4 micron (a hundredth the thickness of a human hair), employing a commercially available optical projection system called a *stepper aligner.* Without the coating, the stepper is limited to the production of circuit lines twice as wide.

This 50 percent reduction in circuit widths of the new coating results in improved operating characteristics. When employed in the manufacture of circuits with lines 1 micron wide and larger, it helps to make chips with more precisely defined microstructures. Basically, the purpose of the coating is to pick up a faint or blurry image from the optical projection system and convert it into a sharp circuit pattern on the semiconductor wafer.

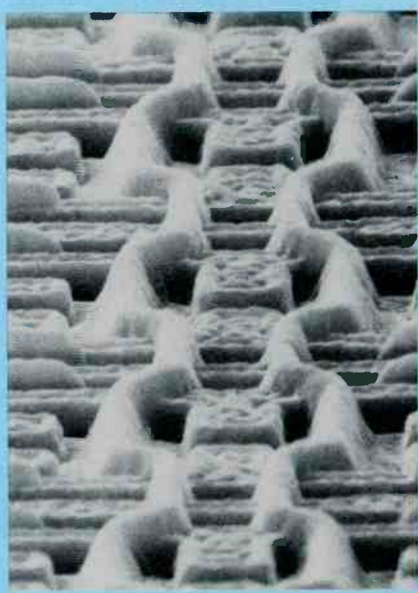
Various types of optical systems used in chip-making are employed to project the image of a tiny circuit pattern (contained on a photo negative-like "mask") onto a semiconductor wafer coated with a light-sensitive photoresist. The wafer is then etched to remove the exposed parts of the photoresist, leaving behind the desired pattern.

This approach has served the semiconductor industry well over the years. However, as manufacturers continue to reduce the size of the transistors and other elements they place onto microchips, the lenses used in optical projection systems have begun to reach the physical limits of what they can resolve.

At present, most commercial microchips have circuit lines with widths of 2 to 4 microns – although 1.5-micron chips are beginning to appear in the marketplace. As semiconductor manufacturers press toward 1 micron, the projected circuit images tend to be blurry and poorly defined because of lens resolution limitations, making it difficult to produce chips that meet specifications.

The material overcomes this limitation with the aid of a proprietary *photo-bleachable* dye. Normally this dye is opaque, but becomes transparent when exposed to light of a certain wavelength.

When a circuit image from an optical printer is focused onto a wafer coated with the contrast-enhancement material, the areas that see the highest-intensity light (areas where there is no circuitry) bleach through first, becoming transparent. This creates a window in the material where light can shine onto the underlying photoresist. Thus, the material acts as an in-situ mask on the wafers, providing sharp differentiation in the projected image between light areas (no circuitry) and black areas (circuitry).



Scanning electron micrographs (8000X magnification) of identical microcircuits produced with (Photo B) and without (Photo A) General Electric's new contrast-enhancement material dramatize the marked improvements in structure geometry that can be achieved with the new technique.

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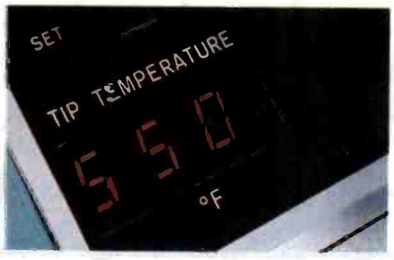

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Circle (6) on Reply Card

By using the "contrast-enhancement" material, it will be possible to make next-generation microelectronic "chips" containing small circuits with present generation processing equipment. Employing a spin coating apparatus to apply the material is GE's R&D Center chemist, Dr. Paul West.

Structures produced with this technique are extremely well formed (uniform line-widths, nearly vertical wall profiles, etc.), even with submicron circuit lines and spaces. The special dye used in the contrast-enhancement material has a combination of characteristics that makes it suitable for this application. Most important among them is its capability of absorbing light selectively. Also, the dye is compatible with common photoresist films.

Only two steps are required to implement the process. One, to apply a thin (0.3-micron) layer of contrast-enhancement material (this is done with a spin-coating apparatus identical to that employed to apply photoresist), and the second to remove the material after the wafer has been exposed.

The contrast-enhancement material is removed in the same chamber in which the wafer is developed. The chamber is programmed so that one of its extra *dispense heads* can be employed in the first part of the cycle to spray on a stripping solvent. After this is done, the wafer is spun dry and developed in the usual way. The stripping operation adds about 30 seconds to the overall process.

To demonstrate the contrast-enhancement process, the GE researchers have fabricated numerous test structures and circuits with minimum feature sizes ranging from 2 microns to 0.4 micron. In all cases, a significant improvement in the definition of the circuit elements and structures has been demonstrated. ES&T

Optical information storage

Possible replacement for magnetic tape

Magnetic materials used as a memory for storing information have been studied for many years at Philips research laboratories. One result of fundamental studies of iron oxides is that magnetic tape for many applications, (including storage of large quantities of alphanumeric data and audio and video recording), has been produced for many years. As the use of these storage techniques increases and user requirements become more specific, various failings of the method became apparent. Storage capacity is limited and the information is only reliable for a certain time because of demagnetization. Because the law may require that information should be stored for a long time, it becomes necessary to copy the information every few years in order to guarantee its reliability. Furthermore, a disadvantage of magnetic tape is that it may take a long time to locate a particular item.

Electro-optical techniques originally developed for LaserVision and the Compact Disc may provide a promising alternative, because they are used for the storage of images and sound and are centrally produced. However, it is also possible for the user to store and retrieve information. In some cases, this information stored locally can be erased and replaced by new information. The major advantages of the new optical techniques are the larger storage capacity and more rapid access to the information.

Briefly, an electro-optical recording system consists of a disc

(Continued on page 44)

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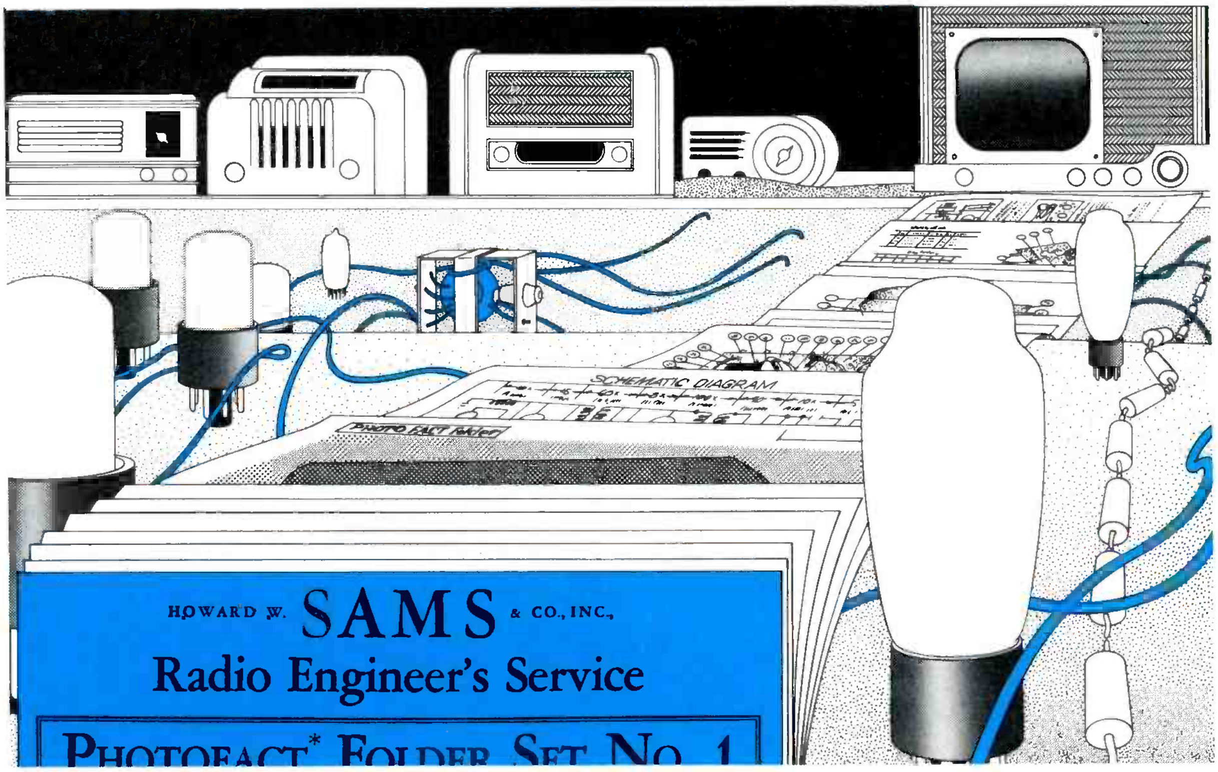

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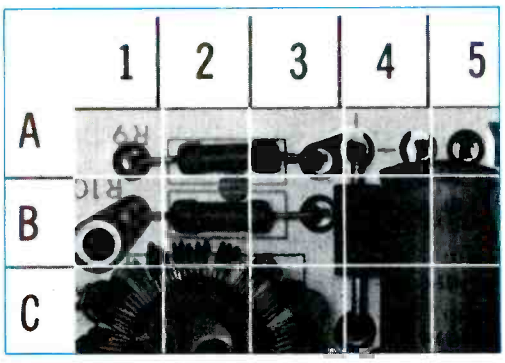

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Introduction to satellite TV receiving systems

By Martin Clifford, Technical Consultant, KLM Electronics

Of all the components in a TVRO system, the dish is possibly the most important, and yet it is the only device in that system that is passive and non-electronic. Often incorrectly referred to as an antenna, it is just one part of the antenna system, functioning only as a microwave signal reflector.

Although it is a simple device, its selection, installation and orientation are critical. Because of the large surface area exposed to the wind, the wind loading factor of the dish (its ability to resist air pressure) is significant. The dish must have a clear line of sight to all the satellites whose signals are to be received. Finally, it is imperative that the dish remain permanently in its installed position, not deviating even slightly.

Not all areas are suitable for the installation of a dish, and, because considerable effort and expense may be involved, it is necessary to make a preliminary site survey, a sort of on-location feasibility study. Not difficult to do, the site survey shows what satellites will be available, and what changes in dish location, if any, need to be made. Satellite signals are high-frequency microwaves, which can be blocked partially or completely by buildings or terrain, or by trees, leaves and shrubbery.

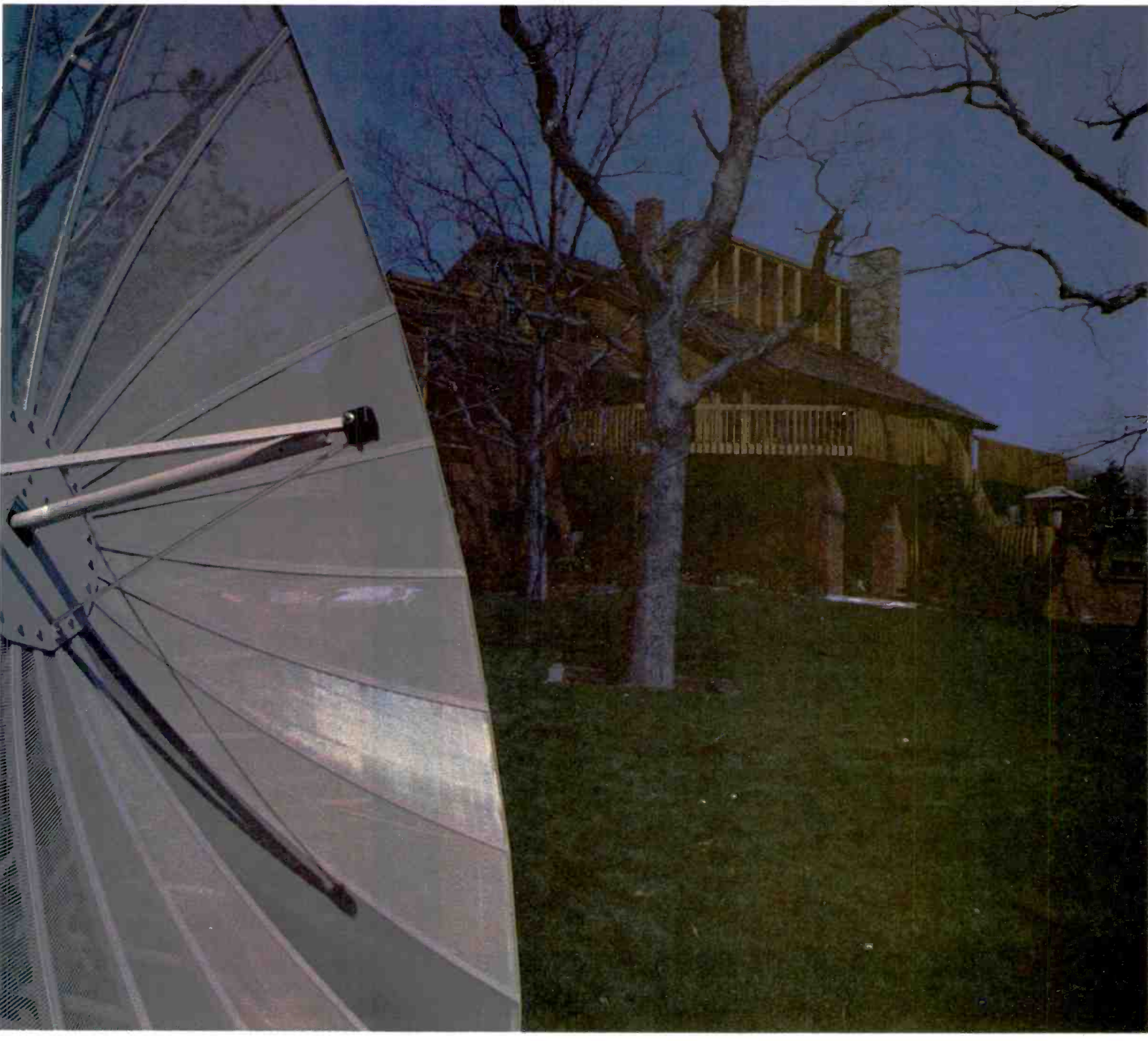
Before doing a site survey, make a few preliminary checks. Overhead power lines can generate electrical noise; there may be underground telephone lines, power lines or other obstructions. Check local building codes to learn if there are any building restrictions.

A dish having a diameter of 10 feet or more (known as its aperture) requires a clear space of approximately 12 feet on each side of a square. It also needs a clear space of about 12 feet to clear the top of the dish. Because the signals picked up by the dish ultimately need to be delivered to the home, a site as close to the home as possible is desirable, with a maximum of about 300 feet in difficult locations. In many instances, site selection is a matter of compromise.

Following the preliminary "look around" site study, it is necessary to use a site tester. The site tester looks similar to a miniature telescope, although it has no lenses. It is equipped with an elevation plate calibrated in degrees, a bubble glass to keep the tester absolutely horizontal and a compass.

When using the site tester, you must know the azimuth and elevation headings for each of the satellites from your location. It is also necessary to have the magnetic deviation. This information is often supplied by dish manufacturers or can be obtained from commercial services, with the data in the form of a computer printout. The magnetic deviation is available from a local airport. Using the site tester is easy following the detailed instructions it comes supplied with.

The device for supporting a dish, either holding it in a single fixed position or permitting the dish to turn in an arc, is known as its mount. There are three types: fixed, Az/El and polar. Of these, the polar mount is the most popular. The most obvious function of the mount is that it must support the dish, which requires that the mount support the weight of the dish and resist wind thrust.



The fixed mount is not only the simplest of the three types; it has a number of advantages. Once it is constructed and the dish is properly adjusted, no further changes are required. It is the least expensive to assemble and requires no drive motor and no voltage operating source. It is also suitable for roof mounting, assuming the structure of the roof can tolerate the weight and thrust. This type of mount is often used by cable companies and newspapers, but, depending on the dish that is used and its focusing arrangement, is usually limited to single, or possibly two, satellite pickup.

The azimuth/elevation mount (Az/El) has two separate axes of rotation: azimuth and elevation. These adjustments are independent of each other and can be done manually, although the Az/El does lend itself to motor operation by remote control.

The Az/El does present an operating problem. Making an adjustment in azimuth usually changes elevation and vice versa. Consequently, it is often necessary to work back and forth. The advantage of the Az/El over the fixed mount is that it can be used to sight more than one satellite. The Az/El is sometimes used to aim at a particular satellite and then to fix the mount into a locked position, thus changing it to a fixed mount type.

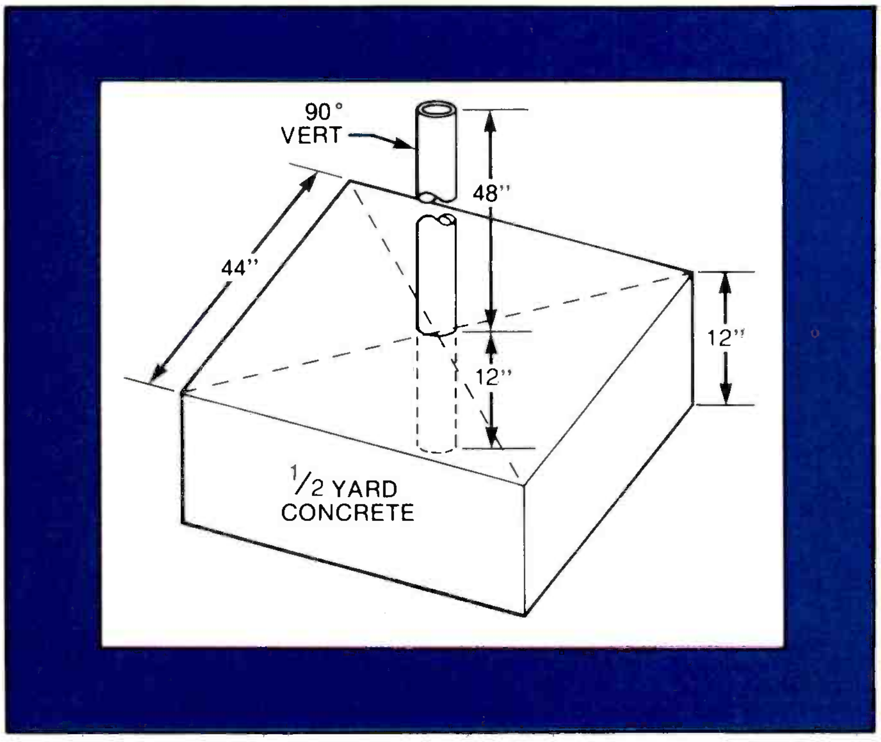
The polar mount is the most popular type for TVROs because azimuth and elevation adjustments are handled simultaneously. For this reason, this mount is used when the dish is to pick up as many satellites as possible. The polar mount can be adjusted manually at the dish but it lends itself well to motorized control from the home. With Memory Track – Polar Trak units the dish can be set to receive any desired satellite simply by pressing a previously set pushbutton.

Not all polar mounts are alike. Some have a limited satellite tracking ability, while others permit the dish to make a complete sweep. If the dish is unable to "see" more than two or possibly three satellites, having full dish sweep is an unnecessary luxury.

Ideally, a dish should collect the maximum amount of microwave signal energy possible and reflect all of this energy to the focal point of the feed, the entry area of the waveguide leading to the antenna probe and the LNA. As far as the feed is concerned, the dish is the signal source, and presumably that signal source delivers all its signal energy to the feed.

This, of course, is not the case, any more than a transmission line delivers all its energy to the antenna input terminals of a TV receiver. While the space between the dish and the feed is open, energy is delivered via that space; in a sense it is comparable to a transmission line.

Because not all of the microwave reflected energy reaches the feed or is used by it, consider the space between the dish and the feed as having a voltage standing wave ratio, or VSWR. This is the relationship between the utilized energy and that which is repeatedly reflected. The lower the value of this ratio, the better. In an ideal arrangement, it would be 1:1, or unity. A representative value would be 1:2.



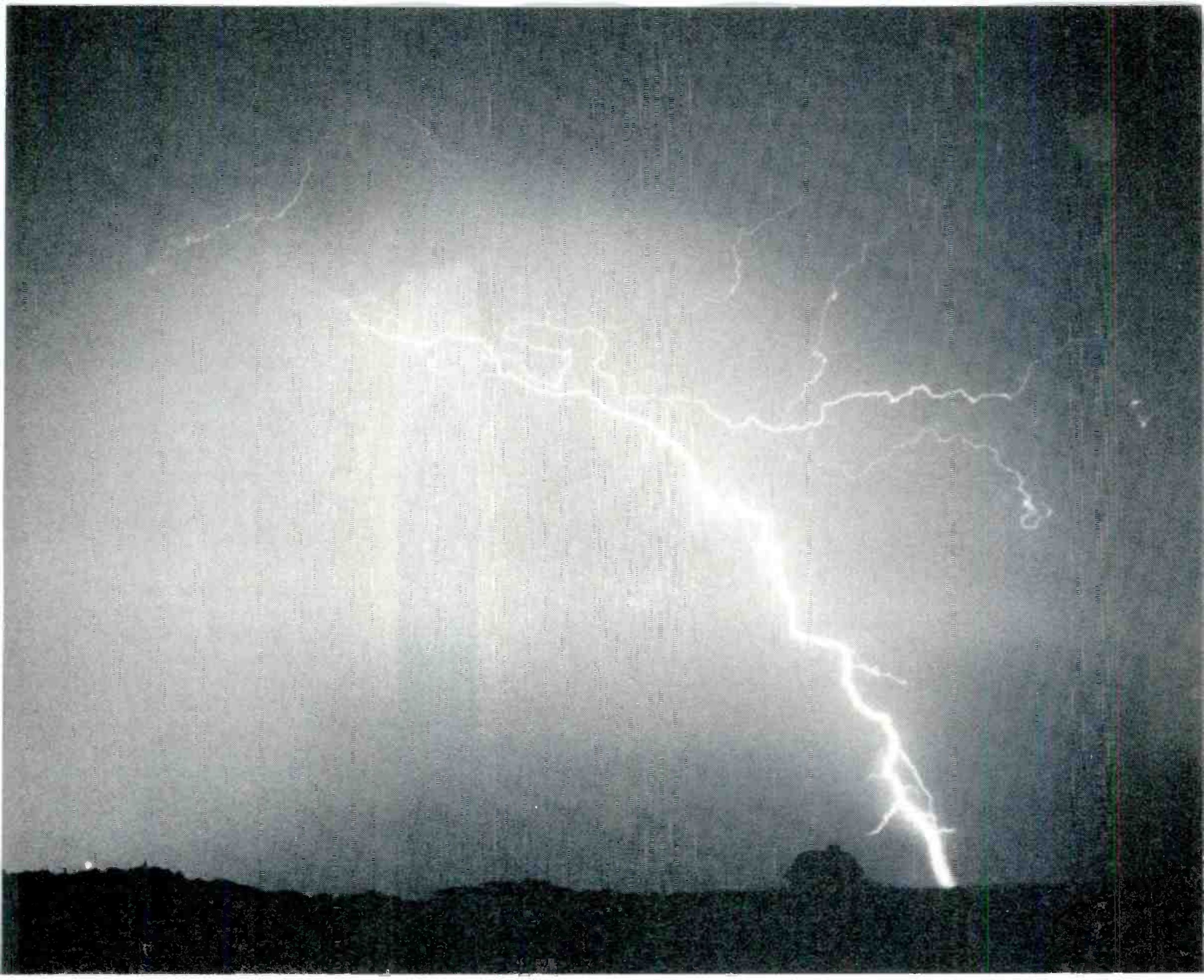
Because a TVRO dish presents a large surface to wind, it is important that it be properly anchored.

Any ordinary FM or TV antenna may be described in terms of its gain. Because the antenna has no amplification, it may seem odd to describe the component this way. Gain is a measure of the effectiveness of a unidirectional antenna in comparison with a reference standard, a half-wave dipole.

The same concept is applied to dishes and, in this case, the theoretical gain is directly related to dish aperture. Gain is important because it is indicative of the signal collecting ability of the dishes with representative values between 35 and 45dB. Higher values of gain are desirable because the ultimate quality of the picture as seen on the TV screen depends directly on it.

A 6-foot dish may have a gain of about 35dB, with an increase of 1dB for each 1-foot increase in diameter. Above a diameter of 11 feet, the increase in gain is only about ½dB per added foot.

The gain of a dish is also dependent on its adherence to a true



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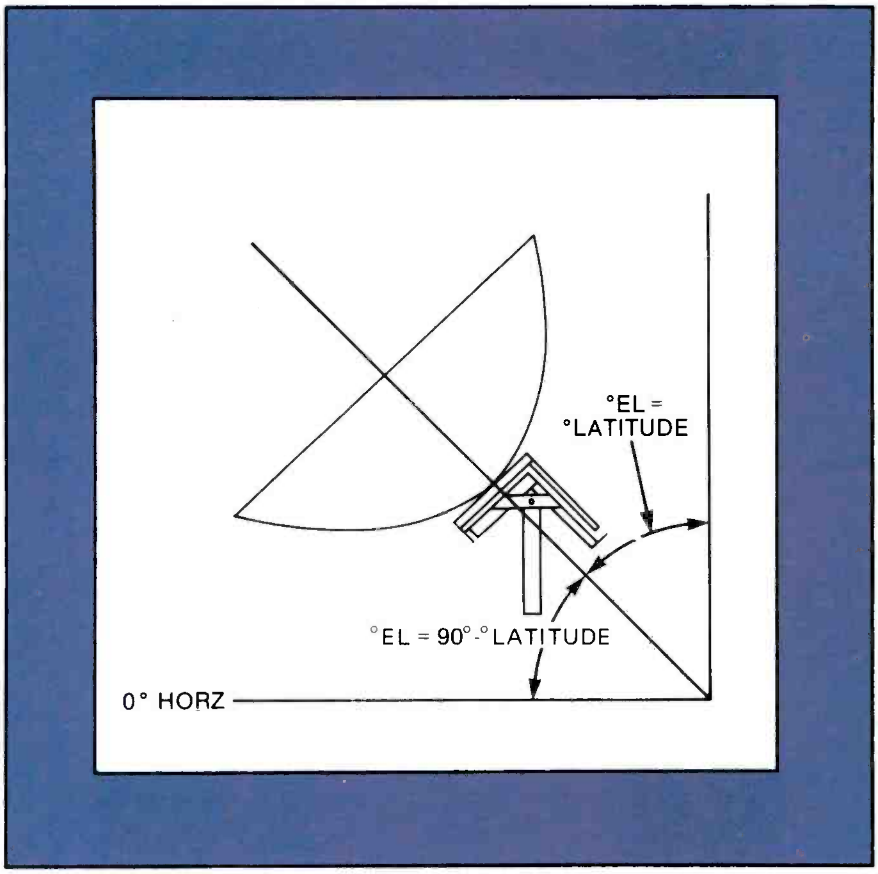
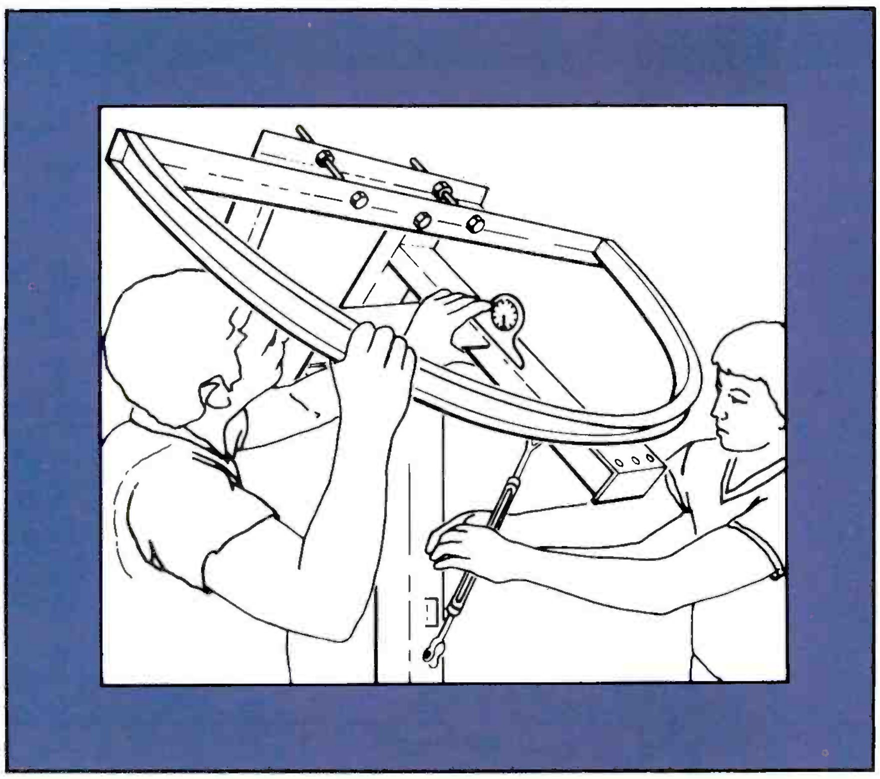


Art 2. TVRO dish elevation depends on geographic location.



Art 3. An inclinometer is used to adjust elevation of TVRO dish.

curve, whether that curve is parabolic or spherical. If a dish warps in transportation or in use, there will be a directly related drop in gain. Although gain is specifically related to the dish, the accompanying feed, a small section of either cylindrical or rectangular waveguide and the antenna probe are all part of the dish system, and therefore contribute to the gain. The use of a series of concentric metal rings near the feed entrance also increases the resultant gain.

The microwave signal delivered by a transponder to a satellite dish is extremely small. Typically, the dc power input to the final power amplifier stage in the downlink transponder transmitter is 5W dc. This signal must not only travel approximately 22,300 miles to the dish, suffering attenuation in the form of space loss on the way, but the signal is spread over an extremely large area comprising about one-third of the earth's surface. The loss in space is about 200dB with a final microwave signal level of about 25 x 10^{-17}W. This signal level is less than the thermal noise surrounding it, so right from the start the battle is one between signal and noise, with noise in this respect indicating electrical noise.

Electrical noise is produced by a combination of factors, but primarily consists of thermal noise and noise due to the transmission of signal in other services using microwave frequencies. Thermal noise is caused by molecular thermal agitation of the earth's surface, but is also produced by the heating effect of ambient temperature, not only on the dish, but on other outside components of the TVRO system. Electrical noise ultimately appears on the TV screen in the form of horizontal rectangular glitches known as sparklies.

Generally, the relationship between a dish and the feed is considered from the viewpoint of the dish with respect to the feed. It is also possible to think of it as if the feed were looking at the dish, as indeed it does. If the feed "sees" the entire dish, from one point on the dish to a diagonally opposite point, the dish is said to be fully illuminated. This isn't as hypothetical as it sounds for it means that all the collected signal energy is delivered to the feed, which is a desirable condition.

It is also possible for the feed to see beyond the edge of the dish, but in this case it would pick up additional noise without receiving additional signal. As a result the overall signal-to-noise ratio would be reduced. In an opposite situation, the feed would see just a relatively small area of the dish, and in that case would receive an inadequate amount of signal, possibly not enough to produce a good picture. Proper illumination is important and is a measure not only of correct dish curvature but of the correct placement of the feed with respect to the dish, and the design of the feed.

A dish is not a tuned circuit in the accepted sense of the phrase, but selectivity is associated with a dish because it can accept the signals of transponders of one satellite while rejecting signals from other satellites. A measure of the ability of a dish to do this is known as its beamwidth, an important characteristic because all satellites use the same downlink frequencies.

Beamwidth is calculated by having the dish face a selected satellite as accurately as possible. Under these circumstances, the dish might have a gain of 38. The dish is then adjusted until the gain drops by 3dB and the measurement in azimuth is recorded. The test is done twice, once to the east and again to the west of the starting point, or zero degrees. The total sweep in azimuth could, as an example, be three degrees. This indicates that a movement of 1.5 degrees either way would produce a signal decrease of 3dB. Generally, beamwidth is measured at the 3dB point. The narrower tha bandwidth the more selective the dish. One of the advantages of a dish having a larger aperture is that it is more selective.

Dishes are made of a variety of materials, but they all have one factor in common – every dish must be metallic. Some may not appear metallic because they are covered with fiberglass, but the fiberglass is simply protective and is not part of the reflective surface. The metal used in the dish can be stainless steel, aluminum or wire mesh.

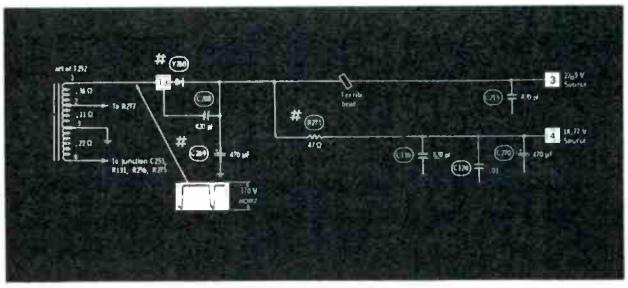
Dishes may be made of a solid sheet of metal or can be in petallized form. The solid dish does not require assembly at the site, but does present shipping problems because the dish surface must be carefully protected. Dishes are often made of wire mesh, which is advantageous in reducing wind loading and in lower dish weight. These can also be petallized and are generally available in a variety of colors, with the protective paint bonded to the surface rather than simply painted on. ES&T

Troubleshooting Tips

Partial raster
General Electric 19XA
(Photofact 1644-1)

Most of the GE b&w receiver's raster was missing. Only about a fourth of the screen area (the lower left corner) had scanning lines. Although the missing area varied somewhat, the variations were not synchronized to picture changes and therefore were no help in pointing the type of defect.

The entire picture was not squeezed into the small visible rectangle. Apparently, the missing raster was being blanked-out. My experience has shown two general sources for problems that shade rasters from top to bottom (or side to side) or that remove sections of rasters by some kind of blanking. One kind originates in the blanking circuit, and the defect widens or otherwise distorts the original horizontal or vertical blanking pulses so that essential parts of the picture are removed. The second general source of misshapen blanking or shading sawteeth often is open or partially open capacitors. These can be bypass or filter capacitors in either B+ or AGC circuits.



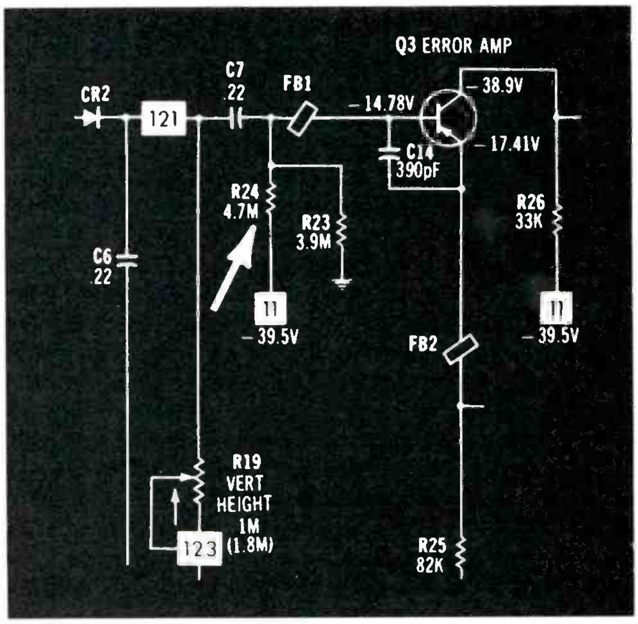
Many of these incorrect conditions can be verified and identified by scope waveform analysis. But for open filter capacitors, it is easier to parallel them with a known-good test capacitor. Remember to turn off the receiver before attaching the test-capacitor leads. Then turn on the power and notice the performance. Before removing the test-capacitor leads, turn off the power.

As I followed by own advice and paralleled the test capacitor across the most likely filter and larger bypass capacitors, the missing section of raster was restored when I paralleled C269, a 470μF filter capacitor of the +22.3V supply.

René Rodriguez
Puerto Rico

Height variations
RCA CTC85
(Photofact 1800-1)

When power was applied to the receiver on our test bench, the vertical height was excessive, with part of the top and bottom missing. Adjustment of the vertical-height control produced normal height but caused a bright drive line horizontally across the center of the screen. After the receiver operated for about five minutes, the height would pull down from the top until only the bottom half of the screen showed a picture.



A new MDG001A vertical module was not available for replacement, so I sprayed canned coolant on the vertical transistors in turn. When Q8 was cooled, the screen would have full height for another five minutes or so. Dc voltages at P2-10, P1-5 and P1-4 all measured around zero instead of more than −17V, as is normal between those points and ground. Because C7 removes any dc voltages of the Q1/Q2 oscillator stage from the Q3 through Q6 amplifier stages, this indicated a problem in the latter stages. And the large out-of-tolerance dc voltages hint that the source might be in the Q3 stage.

Q3 and all resistors around it was checked carefully, and I found 4.7MΩ R24 was completely open, although there were no visible signs of damage or overheating. Installation of a new R24 resistor removed the drive line and gave linear but insufficient height. A slight readjustment of the vertical-height control completed the repair.

Carl E. Jennings
Del City, OK

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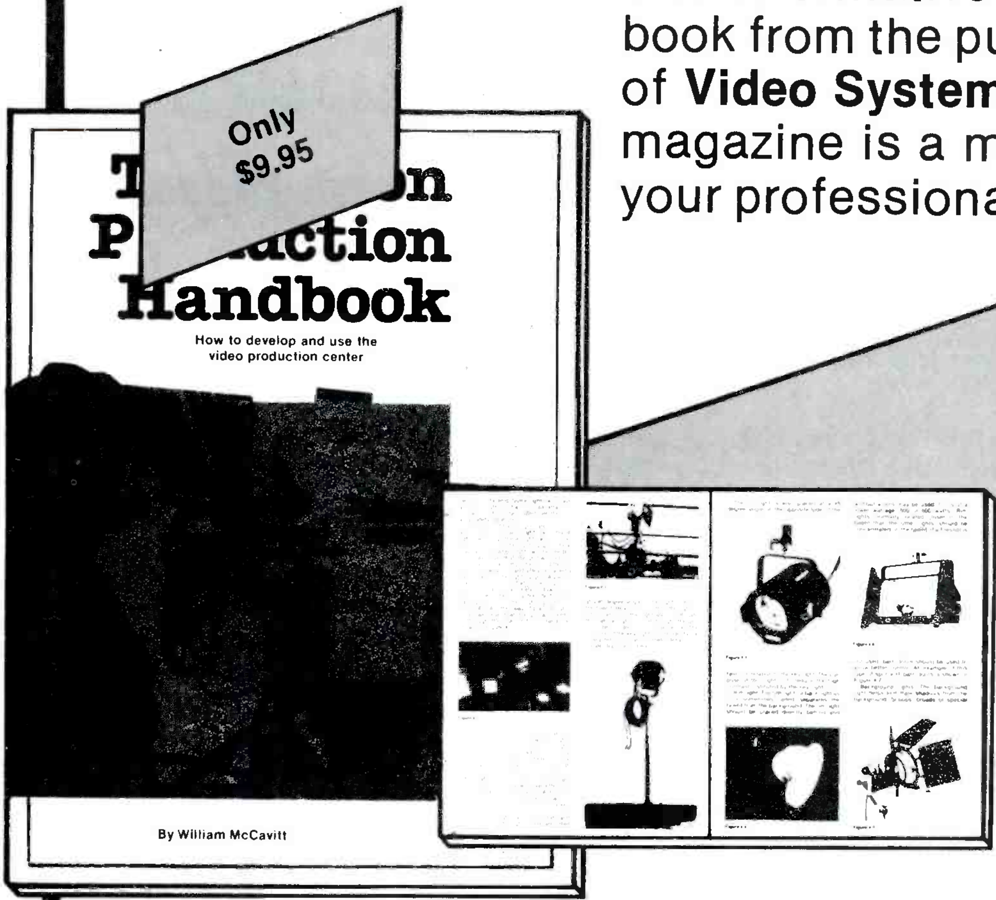

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PART 1

Low-power microwave generators

By Joseph J. Carr

Material in this article is based in part on the author's contribution to James Coleman's book **Microwave Devices**, which is available from Reston Publishing Company, 11480 Sunset Hills Road, Reston, VA 22090.

Microwaves are those frequencies above about 1 gigahertz (1GHz = 1000MHz). Until recently, few people had to concern themselves with microwaves, but now an ever expanding number of devices use those frequencies. There are police speed radars, certain avionic instruments, radio/radar telemetry and other devices. The upsurge of activity in Multipoint Distribution TV Services (MDS) and satellite TV reception has created a whole new line of products that use microwave signals both as transmission media and for local oscillators in receivers and down converters. Thus, more and more people now have to concern themselves with the oscillator circuits used to generate low power microwave signals. This article discusses these circuits. Not covered are high power oscillators used in microwave ovens, airborne and marine radar, and certain communications applications.

Vacuum tube methods

Vacuum tubes made before World War II ordinarily did not operate at either UHF or microwave frequencies. They did, however, seem to represent the best approach to researchers hoping to achieve UHF/microwave operation. There were two major problems with vacuum tubes that kept operating frequency low: *interelectrode capacitance* and *electron transit time.*

There are two approaches to the reduction of interelectrode capacitance. One is the electrode size and geometry, while the other is the interelectrode spacing. Reducing the electrode size not always is possible, however, because smaller electrodes do not dissipate the heat generated by the impact of electrons.

Increasing the element spacing in a vacuum tube will decrease the capacitance, but also will increase the transit time. Manipulation of geometry, size and spacing factors resulted in progress made in vacuum tube design, such that operating frequencies up to 450MHz were used in World War II.

As early as the 1920s investigators had noted that electron transit time seemed to be a fundamental limitation in the design of microwave vacuum tubes. Electron transit time is defined as the time required for an electron to travel from cathode to anode. Proper grid control of the electron stream requires that the period of alternating voltage applied to the grid be short compared with the electron transit time. Before WWII it was relatively easy to design around the transit-time problem at frequencies to 200MHz. Frequencies of 800MHz were attained by the 1950s, but normal mode operation at frequencies greater than 800MHz proved difficult to achieve on a commercial scale.

A solution to the transit-time problem was proposed in 1920 by Barkhausen and Kurz (Germany). The Barkhausen-Kurz oscillator (BKO) used a special configuration vacuum tube to generate 700MHz signals. In the BKO tube (Figure 1) the grid

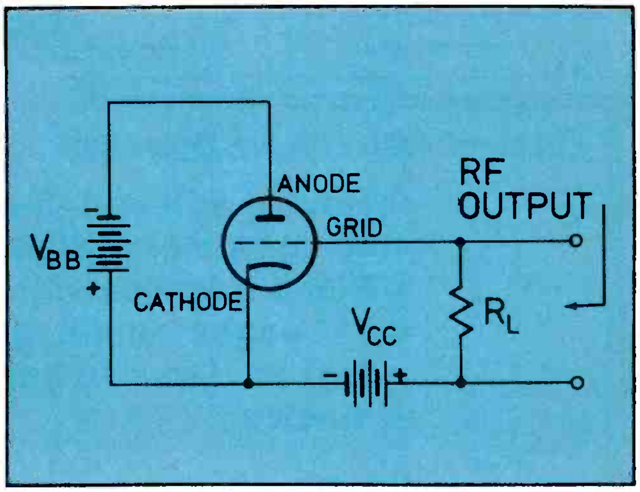


Figure 1. Barkausen-Kurz oscillator circuit.

is made positive with respect to the cathode *and the anode* exactly the opposite of the usual arrangement. Electrons emitted by the thermionic cathode are attracted by the positive potential on the control grid. Some of these electrons will strike the grid, but most are accelerated through the grid structure toward the anode. Shortly after passing the grid, however, they are repelled by the negative potential on the anode and are deflected back towards the grid. The electrons will oscillate in an elliptical path around the grid structure. Output power can be obtained by connecting the grid to a load, and will consist of the minority of electrons in the grid path that actually strike the grid.

The BKO was one of the first devices to overcome the transit-time limitation by making it work to advantage. The BKO overcame the time problem by keeping the electrons oscillating in a circular path in an electric field. The vacuum-tube grid, however, was a factor that limited available output power; its small dimensions often resulted in the grid running white hot during BKO operation.

A solution to this problem was proposed in 1921 by A.W. Hull: delete the grid altogether and keep the electrons in orbit using a *magnetic* field. Hull's original *magnetron* has been modified over the years, but the basic principle is still used today. Most microwave ovens, for example, use magnetron oscillators.

The power-vs.-frequency dilemma seemed unsolvable for several years. But, in the mid-30s, several investigators simultaneously reached similar solutions. Dr. W.W. Hansen (Stanford University) and Drs. A. and O. Heil began to think in terms of turning the transit time to advantage through the mechanism of *velocity modulation* of the electron beam. The Drs. Heil proposed in 1935 to use the electron transit time to control the electron stream. The heating problem was not solved, but was *avoided* because the electrons would not actually strike the control electrodes.

Russell and Sigurd Varian extended Dr. Hansen's work into the practical world in 1937 when they used Hansen's calculations to build the first *klystron* vacuum tube. This device used the transit time and the deceleration of bunched electrons to generate microwave RF energy. Velocity modulation of the electron stream in the klystron produces the bunching effect. It is the time between the arrival of successive bunches at a collector anode that determines the operating frequency of the klystron. Arrival of each bunch represents one cycle of RF energy.

The development of semiconductor devices saw similar, if not identical, problems. The high-frequency response of bipolar transistors, for example, was limited by the transit time of charge carriers (electrons or holes) across the base region. Attempts at reducing the width of the base region in order to decrease transit time produced additional problems, for example, increased capacitance and decreased tolerance to reverse bias potentials.

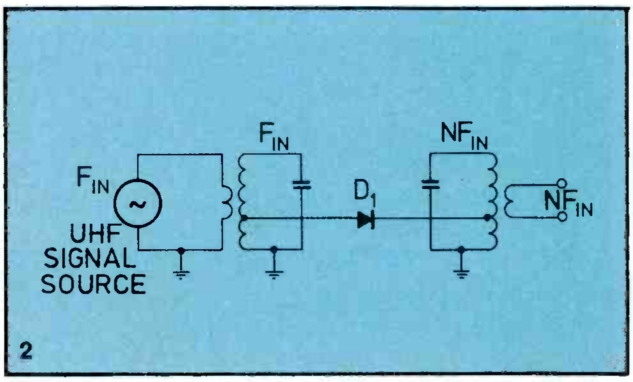
Even thin base regions could not solve the problem. Semiconductor materials exhibit a properly called *electron saturation velocity,* which is analogous to a similar problem in vacuum tubes. This limitation seems to be a fundamental limit to the high frequency operation of bipolar transistors. But, as with the vacuum-tube transit time problem, this problem can be turned into an advantage and used to create microwave oscillations.

An early solution to the problem was the use of *diode frequency multiplers* (Figure 2). A UHF oscillator is used to generate a frequency that is a subharmonic of the desired frequency. The signal is then applied to a fast operating microwave diode

(D1), which distorts the signal and makes it harmonic rich. An output tuned circuit selects the desired harmonic, N (where N is an integer). The tuned circuits are shown here as LC networks, but in microwave circuits they might be stripline tuners, cavities, or some other resonant device. Some of the best generators use totally new effects – the Gunn diode, for example.

Transferred electron devices

John Gunn, of IBM, was studying the properties of n-type gallium arsenide (GaAs) material in 1963. He noted that the current through the material would become unstable if the applied voltage were increased above a certain threshold potential. It was

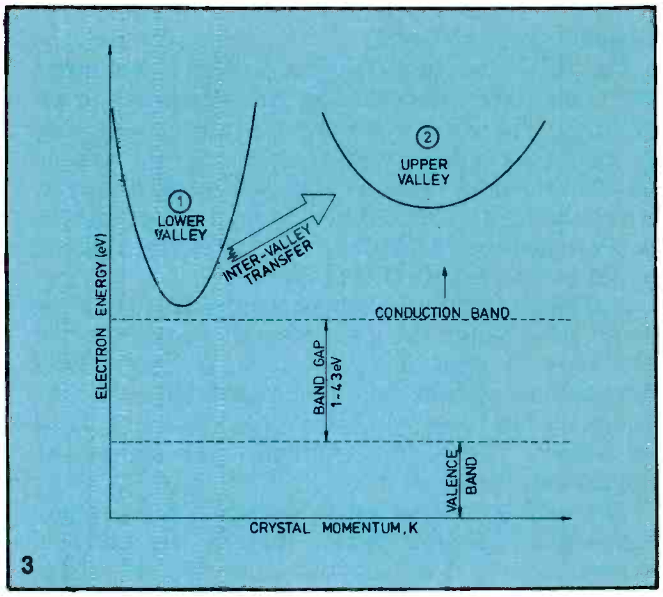


discovered that the current would pulsate at microwave frequencies if the E-field were above this critical point.

Gunn suspected that a negative resistance phenomenon was responsible for the observed behavior (negative resistance generators can be made to oscillate under the right circumstances). Gunn speculated that the negative resistance phenomenon was due to a loss of electron mobility at the higher applied voltage. This theory can be inferred from the fact that some materials, such as GaAs, permit electrons to exist in either of two, rather than just one, conduction bands (Figure 3). In the lowest conduction band the electron-effective mass and electron energy are low. The energy level is close to the minimum allowed for conduction bands in that material. Electron mobility in this conduction band is high, i.e. on the order of 8000 $cm^2/V\text{-}s$, so the material will act like an ordinary ohmic resistance.

If the electric field is increased to approximately 3 to 3.5kV/cm, then the electrons will become more energetic and will transfer to the higher conduction band. An energy level of 0.35eV separates the minima of the two conduction bands. The electron effective mass increases in the higher conduction band, while mobility and drift velocity are decreased.

Figure 4 shows that an increasing number of electrons are scattered into the low-mobility conduction band as the applied potential increases above a certain threshold voltage V_{th}. At potentials less than the threshold potential, the electron velocity increases linearly with the applied voltage. This



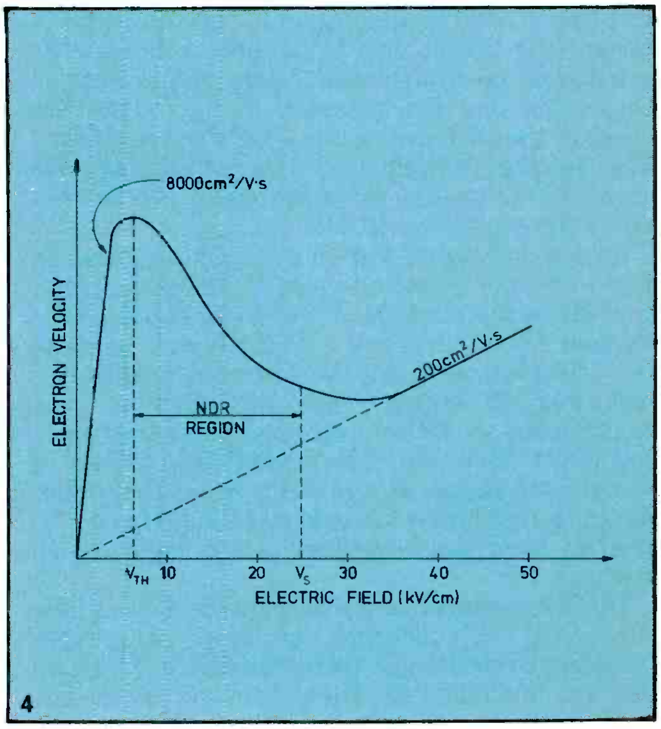


Figure 2. Diode frequency multiplier.

Figure 3. Two conduction band system for TEO operation.

Figure 4. Electron velocity vs. electrical field.

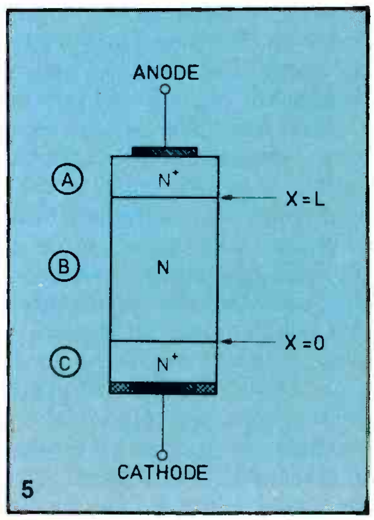


Figure 5. Gunn device.

behavior is exactly as expected in any material that obeys Ohm's law. But at potentials greater than V_{th}, the number of electrons transferred to the low mobility-low velocity conduction band increases with increasing voltage. This phenomenon causes the net electron velocity to drop, creating a negative resistance region between V_{th} and a saturation potential V_s.

Microwave oscillators that depend upon the transfer of electrons between high- and low-mobility conduction bands are called *transferred electron oscillators (TEO).*

The description of negative resistance operation adequately justifies the claim that the GaAs material will oscillate, but does not explain the structure of the Gunn device or the mechanism of oscillations in these devices. There are two different modes of oscillation in the Gunn device.

Incidentally, it has become common practice to call the Gunn device a "Gunn diode," but this is not strictly correct: the Gunn device is not a diode. The Gunn device uses oscillations in a bulk medium, not a PN junction. The diode-like structure of the Gunn device shown in Figure 5 is not an ordinary PN junction. The end sections are not active, but are intended to facilitate ohmic contact between the electrodes and the active center region. Also, it is the practice of some people to refer to most solid-state microwave oscillators as Gunn diodes, even those that are of an altogether different structure. One recent advertisement listed as a "Gunnplexer" a device that contained an IMPATT diode. The Gunn device is a diode only in the sense that it has two electrodes but it should not be confused with PN junction diodes. Gunn devices are used to generate CW radar signals, as in police speed radar transmitters.

Gunn devices

The observations of Gunn in 1963 led to the invention of the Gunn device as a microwave oscillator. But, negative resistance oscillators were the subject of speculation by Shockley as early as 1954. Esaki (1956) had produced a 2-terminal "diode" device that exhibited a negative resistance property. This device is now known as the *tunnel diode* or *Esaki diode.* Sommers suggested in 1959 that the Esaki diode would have microwave applications, a prediction that has proven accurate. It was against this background that the Gunn device was invented in the mid-60s.

Gunn device structure

The basic structure of the Gunn device is shown in Figure 5. This device consists of three basic sections, labeled A, B, and C. Region A provides ohmic contact with the active center region, so should be made of relatively low resistivity (0.001Ω-cm) material. Its purpose is to ensure good contact with the end electrode and to prevent metallic ion migration from the electrode into the active region. The thickness of region A is approximately 1 to 2 microns, and it is grown epitaxially onto region B.

Region B is the active region in the Gunn device and consists of n-type gallium arsenide. The oscillating frequency of the device in one of its two modes depends on the thickness of this region, varying from 6GHz at 18μM to 18GHz at 6μM.

Region C is the substrate layer and is metallized to allow bonding to the device support structure: the "diode package." Again, low resistivity GaAs material is used.

Gunn devices are not very efficient, especially in the transit time mode of operation. These devices may require 20 to 50 times more dc power than they produce in RF output. As a result of the low efficiency, the substrate is usually bonded to a heatsinking package.

Modes of oscillation

The Gunn device can operate in either of two modes: *transit-time* (or *Gunn) mode* and the *limited space-charge (or delayed transit-time)* mode. The transit-time mode depends on the thickness of the active region for operating frequency, but does not require an external tank circuit for proper operation. The delayed-transit time mode requires an external tank circuit, i.e a tuned cavity, but is frequency-flexible and operates with more efficiency.

Transit-Time (Gunn) Mode

When a Gunn device is biased below the threshold potential V_{th}, the electric field will be uniform throughout the device (Figure 6A). The Gunn device will operate as an ordinary positive resistance in the region; the current will increase proportionally with the increasing voltage.

But in the situation (Figure 6B) when the Gunn device is biased to the threshold potential V_{th}, electrons are injected into the cathode end of the material faster than they are collected at the anode end. This causes a domain to build up that is rich in excess electrons on one side and deficient in electrons at the other side (the depleted region is on the anode side of the domain). This domain drifts through the length of region A in the Gunn device until it is collected at the anode end. A new domain forms as the old domain is collected at the anode.

The current output from the Gunn device maintains a low background level (Figure 7) until the domain is collected at the anode. At that instant a brief current pulse is generated in the output circuit.

The period of time between output current pulse peaks is the drift for that particular sample of material. The period, hence the operating frequency, is dependent on the path length and the drift velocity (on the order of 10^7cm/s) of the domain.

Delayed-domain mode

The delayed-domain, or limited space-charge (LSA) mode is more efficient than the transit-time mode. The transit-time mode, while elegantly simple, suffers from low efficiency and a frequency limitation that is determined by the thickness of the active region. The delayed-domain mode allows the Gunn device to adapt to the frequency of an external tank circuit, such as a high-Q resonant cavity.

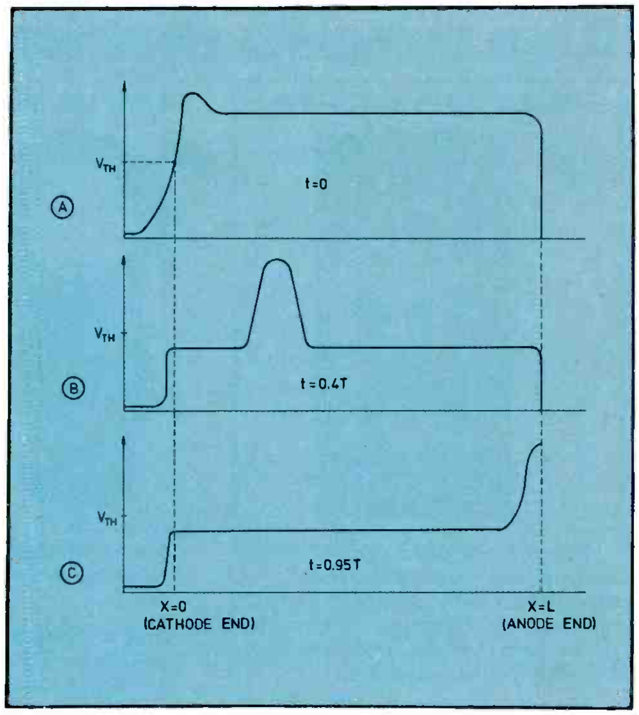


Figure 6. Gunn domain operation.

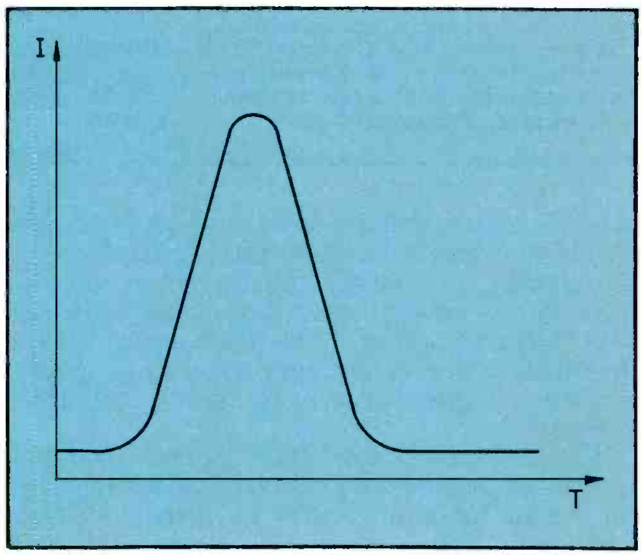


Figure 7. Output current pulse.

Figure 8A shows an equivalent circuit in which the negative differential resistance (NDR) of the Gunn device is shown as a negative conductance placed in parallel with the LC tank circuit. Conductance G represents the ohmic losses in the tank circuit. The circuit will oscillate if $|-G_0| \geq G_0$.

Suppose that we bias the Gunn device at some potential greater than the threshold voltage. The domain-creation phenomenon of the transit-time mode will cause several initial output pulses to excite (i.e. "ring") the external tank circuit into oscillation. This action will cause a continuous RF sine wave to build up (see Figure 8B) that has a frequency equal to the resonant frequency of the tank circuit. The RF voltage adds algebraically with the static dc bias such that the total bias is greater on

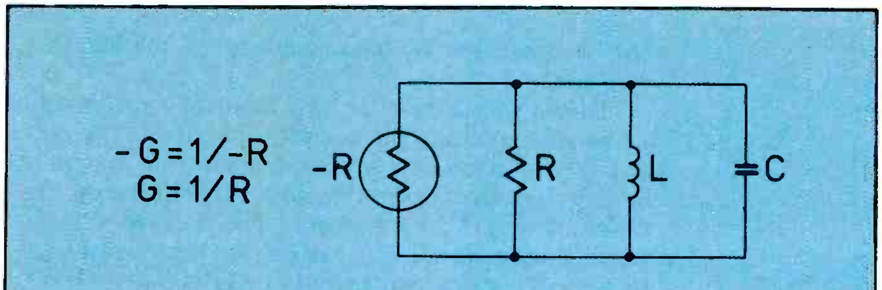


Figure 8A

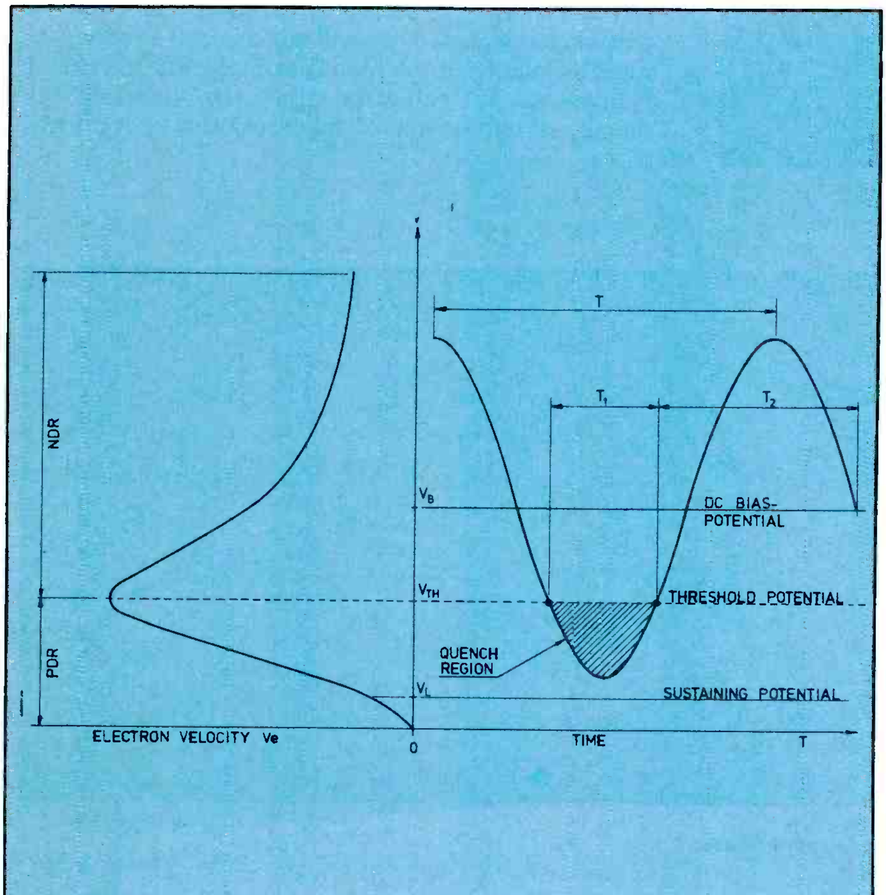


Figure 8B

Figure 8. A) Equivalent circuit of Gunn oscillator places a negative resistance in parallel with an RLC tank circuit, B) LSA Mode operation of the Gunn device.

positive peaks and less on negative peaks. The value of the static dc bias must be carefully adjusted so that the total bias drops below V_{th} on the negative peaks of the RF cycle, yet will remain above the minimum sustaining potential. Whenever the total bias (i.e. sum of dc and RF voltages) is less than the threshold potential, the domains are quenched. If the previous domain reaches the anode while the bias is below V_{th}, then the creation of the next domain is delayed until the RF cycle brings the bias back above the threshold potential. This phenomenon causes the output current pulse period to adjust automatically to the period of the external tank circuit. Figure 9 shows LSA output pulses.

We can use the frequency agility of the delayed-domain mode to frequency modulate the device, or

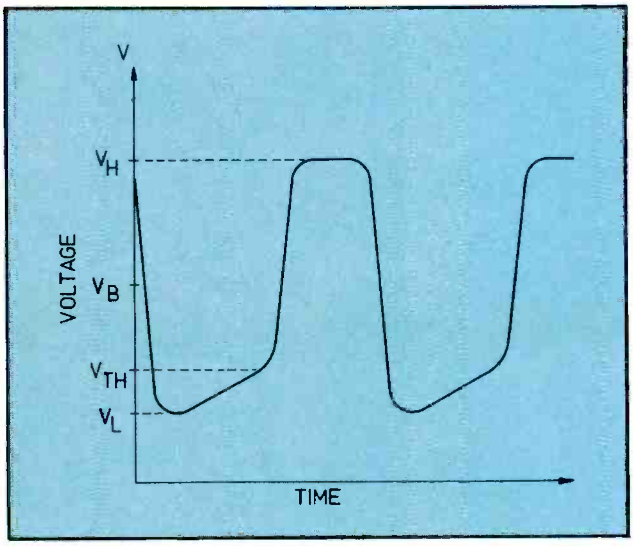


Figure 9. LSA mode output pulses.

make it subject to *automatic frequency control* (AFC) operation by manipulation of the dc bias potential.

The delayed-domain or LSA mode is considerably more efficient than the transit-time mode. The output power available in the transit-time mode is usually less than 1000mW, with efficiencies on the order of only 1 to 5 percent. The delayed-domain mode, on the other hand, can deliver peak powers up to several hundred watts (duty cycle of 0.01 or less). The operating frequency of the transit-time mode is determined by the length of the active region and the saturated velocity of the electrons ($1/f = T = L/V_{sat}$), so is not variable. The delayed-domain mode, however, will adjust itself to the resonant frequency of the high-Q tank circuit in which it is operated. We can often adjust the operating frequency of one octave by adjusting the tank dimensions.

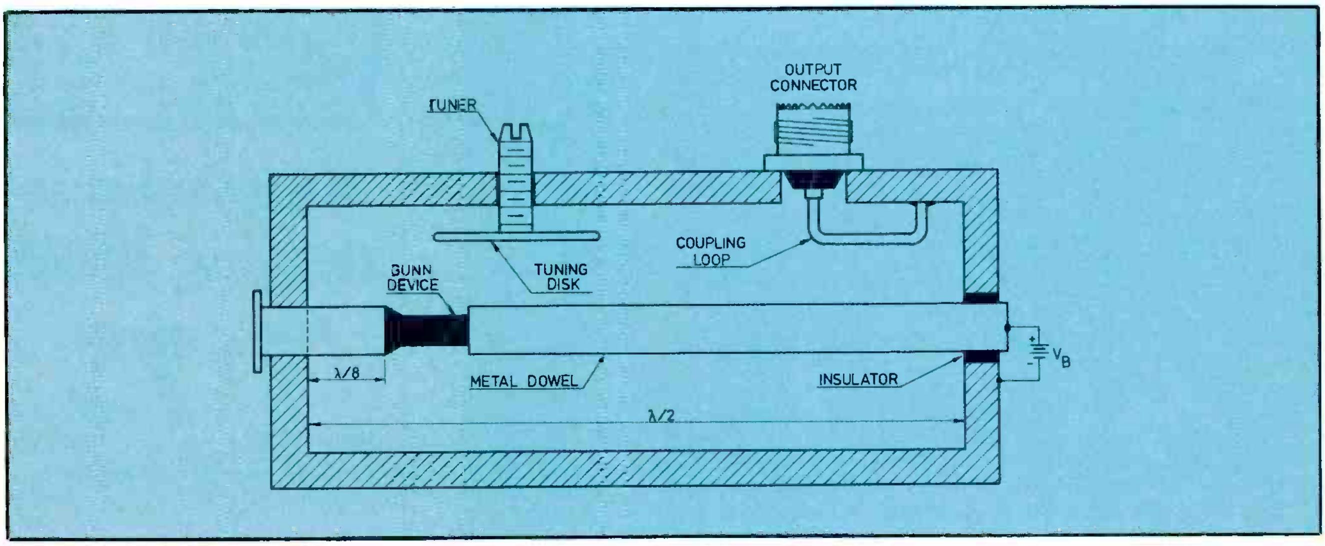


Figure 10. Coaxial tuned cavity operation of a Gunn oscillator.

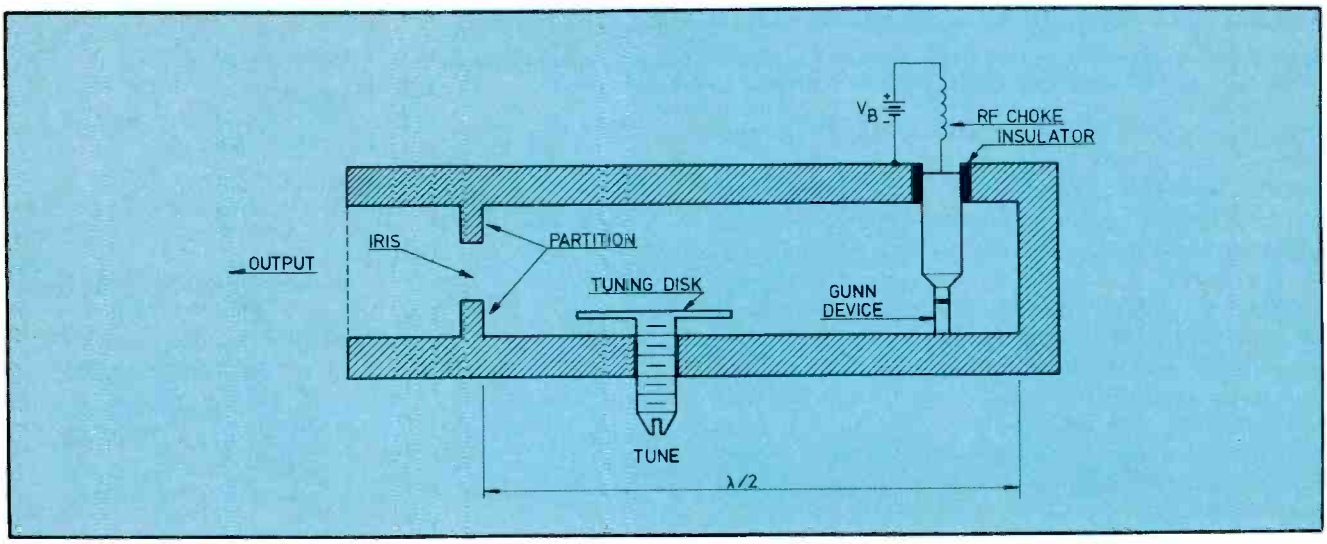


Figure 11. Operation in coaxial or rectangular waveguide.

Gunn oscillators

The Gunn device will oscillate in the transit-time mode using only a simple resistance for the load. The efficiency in this mode, however, is only 1 to 5 percent, so relatively large amounts of dc power are required to generate small amounts of RF power. If we place the Gunn device inside a resonant cavity and bias the device for the delayed-domain mode, the result will be better efficiency and some flexibility of the operating frequency.

Figures 10 and 11 show two methods for mounting a Gunn device inside a resonant cavity. Figure 10 shows a cutaway view of a coaxial cavity. The length of the cavity is half wavelength, while the base of the Gunn device is placed at the one-eighth wavelength point. A conductive *dowel* supports the Gunn device and connects it to the ends of the cavity. The dowel is also the center conductor of the coaxial cavity. A tuning screw is used to vary the operating frequency of the device. It effectively changes the dimensions of the cavity and is capable of fine tuning the operating frequency over a small range.

The oscillations on the inside of the cavity are coupled to the outside world through a short coupling loop that is situated parallel to the dowel center conductor. The load impedance of the Gunn device is set by the position of the coupling loop, and is adjusted for the best compromise between the stability of the operating frequency and the maximum output power.

The coaxial cavity, while simple, suffers from a few basic problems. It is a low-Q tank and is more sensitive to factors such as temperature and load impedance variations. The Gunn device in a coaxial cavity also may tend to oscillate on a harmonic of the tank frequency.

A rectangular waveguide (Figure 11) also can be used as a tuned cavity if one end is blocked off and the Gunn device is placed at the one-eighth wavelength point. dc bias is provided to the Gunn device through an RF choke that is designed for microwave operation.

The dimensions of the cavity are determined by the placement of a partition. Energy from the cavity is coupled into the waveguide transmission line through an opening called an *iris*. The size of this iris is a trade-off between maximum output power and a sensitivity to changes in the load and internal impedances of the Gunn device.

The second part of this series will discuss several other types of solid-state microwave generators. Included are IMPATT devices, TRAPATT devices and BARITT devices.

Material in this article is based in part on the author's contribution to James Coleman's book **Microwave Devices,** which is available from Reston Publishing Company, 11480 Sunset Hills Road, Reston, VA 22090.

ES&T

Test your electronic knowledge

By Sam Wilson, CET

1. Which of the following is a method of getting into or out of memory by having an I/O device take control of the CPU for one or more cycles?
A. MAD
B. DAM
C. AMD
D. DMA
E. ADM

2. Which of the following is software used to convert a program from a high-level language to assembly or machine language?
A. compiler
B. decoder
C. encoder
D. editor
E. designator

3. Which of the following is a field effect transistor capable of delivering power to a load?
A. VMOS
B. CMOS
C. PMOS
D. MARK IV
E. BEAD LEDGE

4. Back-to-back SCRs can be used in place of
A. a diac
B. a triac
C. a variac
D. an imnac
E. hot carrier diodes

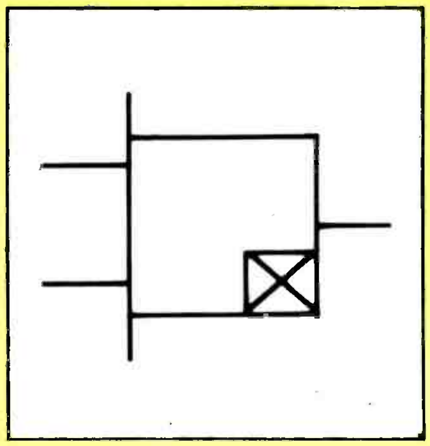


Figure 1

5. Crossover distortion is most likely to be a problem in
A. emitter follower circuits
B. Darlington amplifiers
C. output transformers in power amplifier stages
D. equalizers
E. push-pull amplifiers made with bipolar transistors

6. Which of the following is part of the FM stereo signal?
A. ACS
B. SCA
C. CAS
D. SAC
E. CSA

7. The symbol in this Figure represents
A. an AND gate
B. an OR gate
C. a NAND gate
D. a NOR gate
E. an EXCLUSIVE OR gate

8. Which of the following motors is likely to be damaged if it is operated without a load?
A. stepping motor
B. shunt-wound motor
C. series-wound motor
D. capacitor start motor
E. synchronous motor

9. In a frequency synthesizer you would likely find a
A. PAL
B. PLL
C. PIL
D. PLA
E. VOR

10. A Bode plot
A. compares two frequencies
B. shows gain vs. frequency
C. is used only for computer graphics
D. shows frequency vs. temperature
E. shows resistance vs. frequency

(Answers on page 37.)

Answers to quiz

(from page 28)

1. *D* Direct Memory Access permits the memory to be loaded from outside the computer or microprocessor system.
2. *A* There is something about the name compiler that makes it sound like hardware.
3. *A*
4. *B*
5. *E* Remember that cross-over distortion is prevented by forward biasing the transistors. Unlike push-pull circuits made with tubes, the transistor version uses class AB bias. Tube circuits usually use class B bias.
6. *B* With an SCA decoder the music can be reproduced without the commercials.
7. *C* A NEMA symbol is shown. Unfortunately, there is more than one type of symbol used for logic circuits.
8. *C* A series-wound motor will undergo a continuous increase in speed until the motor destroys itself. There is an exception. Very small motors will sometimes reach a maximum speed before they are destroyed. The reason is that friction provides a mechanical load.
9. *B* A phase locked loop, in conjunction with a programmable counter, is used to select various frequencies.
10. *B* A bode plot shows gain and phase vs. frequency.

Troubleshooting Tips Wanted

Electronic Servicing and Technology needs additional consumer-product Troubleshooting Tips. Most types of case histories are suitable, especially those with unique, puzzling or misleading symptoms.

List the brand, model and Photofact number followed by a narrative telling the original conditions or symptoms, the various troubleshooting steps, and the components replaced to restore the original performance. Please include a simple hand-drawn schematic of the stage that has a defect.

$10 will be paid for each Troubleshooting Tips published. Your name and city will be listed, unless you ask to remain anonymous.

Send all Troubleshooting Tips to:

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P.O. Box 12901
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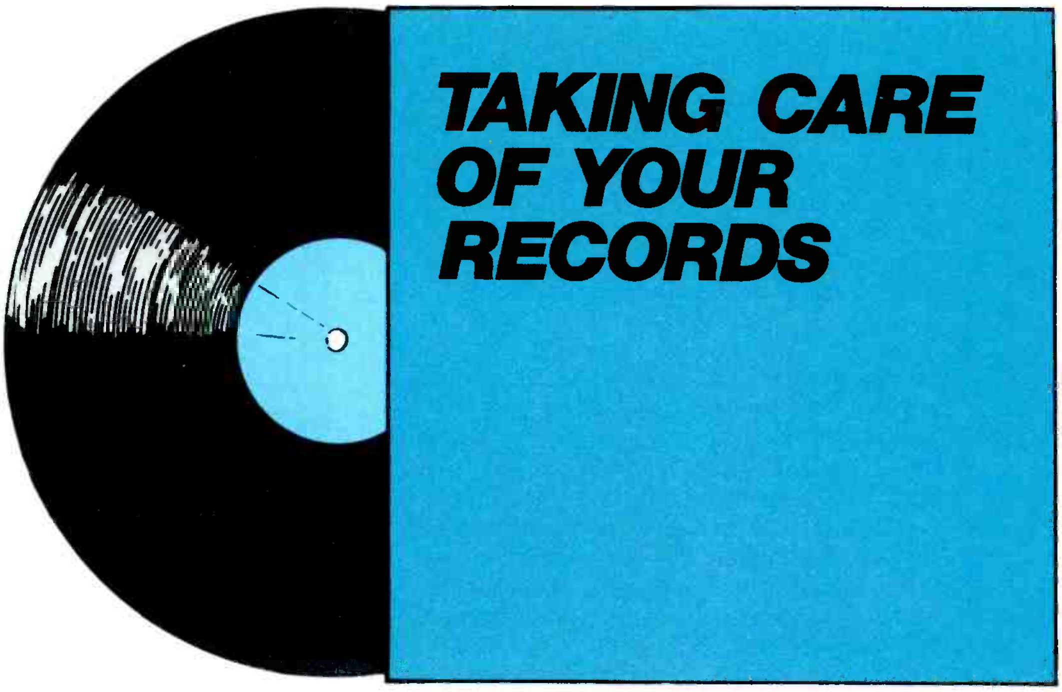

TAKING CARE OF YOUR RECORDS

By Kirk Vistain

Now there's a way to make all your phonograph records last indefinitely. It requires no liquids or potions, no brushes or anti-static guns, no special incantations. In fact, it's so simple, you will feel silly that you didn't think of it. The best way to preserve your records is: *Don't use them.* Leave them in their dust jackets, sealed away from the real world, and the fidelity will be as good as the day you bought them.

You see, no matter how careful you are, every time you use a record, you'll probably damage it a little. Either dust will cling to it because you built up several thousand volts of static electricity when you pulled it out of the jacket, or dust will settle on it while it is playing, or the stylus will slowly grind the grooves to dust and leave yet more residue to reduce fidelity.

Like backaches, record damage is inevitable. For this reason, scores of products are on the market that are designed to mitigate the effects of using phono records for their intended purpose. By the time you've finished this article, it may seem as if every time you decide to play a record, you'll have to spend five minutes per side preparing it, not to mention all the gewgaws and gizmos you'll have to set up to do it.

That's not much of an exaggeration. Record care is a never-ending battle to preserve the sound quality of a medium that audibly degrades every few times you use it. But, considering the price of records, it seems wise to take every precaution to preserve them.

Failure modes

Just what exactly causes records to wear and degrade? For the sake of this article, assume that the record was properly manufactured (something you can't always rely on), and that it hasn't been used for a frisbee or pizza plate. Obviously, avoid fingermarks, grease and scratches.

Barring the obvious, phonograph records are still plagued with three categories of trouble:

1. Static charges
2. Dust, dirt and contaminants
3. Wear

Interactions among all three are common, and while some products on the market try to address one problem at a time, others go after all three at once.

Static

Elimination of static is vital to record care. Modern phonograph records are manufactured from a copolymer of vinyl chloride and vinyl acetate. These compounds are part of a list of chemicals in something called the "triobic" series. What this means is that rubbing a record against almost any other substance it's likely to encounter (dust jackets, styli, human hands, etc.) tends to produce a negative static potential that can be as high as 5 or 10kV.

With that kind of charge on it, a record becomes an inviting home to every piece of floating debris in a 3-foot area. The electrostatic charge bonds dust to the record with thousands of pounds of pressure. Just try to get that stuff out of the grooves with a little brush that runs ahead of the stylus!

Static can also cause mistracking by unevenly attracting the tonearm during play. Annoying clicks and pops also result.

Static control

There are several approaches to static control. One requires the application of an anti-static fluid to the record, which may last for up to 100 plays before retreatment is required. Another uses a piezoelectric element in a small gun-shaped device that is used before each play. It eliminates unwanted charges much as a demagnetizer does on tape heads. A third approach uses a conductive record mat or brush to prevent static buildup during play.

Anti-static gun

This device neutralizes the static charge on the record by flooding it with a stream of ions of the opposite polarity. Usually a record is negatively charged, so cations (positively charged ions) are needed. Unfortunately, static guns also emit anions (negatively charged), which you want to eliminate. Presumably, the manufacturer thinks that records will occasionally become positively charged, but this is not common.

Also, it is a 1-shot treatment that you must repeat each time the record is played or handled. Furthermore, it is possible for a record to build up a 20kV or 30kV charge while playing.

Mats and conductive brushes

Anti-static mats and brushes are OK, but do not seem as effective as a fluid treatment. They also can't do much about the static charge that pulls dust onto the record as it is removed from the jacket.

Fluids

Fluid products need be applied only once every 50 plays or so, and, presumably, solve the problem of static buildup during both handling and play. Most of these are multipurpose compounds, which add a dry-lubricant coating to the record, as well as an anti-static treatment.

Do they work? Lab tests of two major brands, Audio Technica "Lifesaver," and Stanton "Permostat," show a long-term elimination of static charges and reduced record wear. The latter shows up as significantly better retention of high-frequency material on a treated record after 100 plays and slightly lower noise levels (5-10dB at high frequencies).

My own experience with such products corroborates these results, but I've found that the fluids must be applied carefully in order for the improvements to be heard. A haphazard wipe won't do.

Some experts recommend that you play a record several times with a conical stylus to clean dirt out of the grooves after an anti-static treatment. This primarily applies to older records. The particles set free by dissolution of the static charge will build up quickly on the needle until total cleaning is accomplished. Then you can switch to an elliptical stylus, or whatever type you prefer for playing.

Dust, dirt and contaminants

Once the static charge is eliminated, dust buildup slows but can still occur. Remember that a record groove is tiny, and even contaminants that seem diminutive to the naked eye can cause annoying noises and distortion, not to mention damage to the groove. Termed "record micro-dust" by the record care industry, these particles need to be removed at each playing. Among the products available are brushes that mount on the tonearm head, those which have their own separate "arm" and hand-held brushes.

Pads and potions

A proper hand-held cleaner is really a system, which includes the brush and cleaning fluid. Careful attention must be paid to the design of both components or all you'll be doing is pushing dust around and leaching stabilizers out of the vinyl. It's important that the fluid effectively dissolves contaminants without damaging vinyl.

One well-designed product is the Discwasher cleaning system. The brush is made up of a fiber pad whose bristles are small enough to reach deep in to the groove to remove contaminants. It is coupled with a special liquid for which the pad has a great affinity. Thus the majority of the fluid that comes in contact with the record simply dissolves the contaminants and is wiped off by the brush.

This type of cleaner is used just before playing. Most users clean both sides of the record first, but my experience indicates that each side should be cleaned just before it plays. Otherwise, the dust picked up from the record mat causes problems. This seems like a lot of trouble, and it is, but the reward is a record that sounds better and lasts longer than its untreated counterparts.

Brushes

Brushes are mounted on arms installed on the record player base, usually with a suction device or double-sided tape. Most consist of a pad and brush assembly. They track the record much as the tonearm does, except that their job is to clean the groove just seconds before it is played. The pad picks up dirt, while the brush functions to "track" the record groove, simultaneously rooting out dust. Most come with a special fluid to be used on the pad, although the ones I have used seem to work just as well dry.

Some, such as Audio Technica's "Auto-Cleanica," sport conductive bristles that are said to reduce the static charge on the record by effectively discharging it through a wire to ground.

One advantage of these devices is that they clean the groove immediately ahead of the needle, so they can eliminate dust that settles on the record during play.

However, arm-mounted brushes can produce annoying scraping sounds that occasionally are reproduced by the sound system. They may not track correctly, sometimes sliding from the outside to the inside of a record in a matter of seconds. You cannot use them with a record changer unless you set it for manual operation.

Reducing wear

This is an area of great controversy. Some believe that proper de-staticizing and cleaning of a record is all you should do, that a perfectly clean record, if properly manufactured, will provide optimum performance. Others prefer to put a dry lubricant onto the record surface to preserve it. One of the first record preservers was "Soundguard," developed by Ball Manufacturing (the people who brought you Mason jars). This type of treatment is also available in the multipurpose fluids discussed under **Static.**

As is typical in the field of high-fidelity, this is one of those controversies in which both sides have good evidence. The Discwasher philosophy is that proper cleaning is best. Coatings are appropriate only for records that will be abused by patrons of the public library. Coatings can do nothing but obscure the information (albeit with an exceedingly thin film) that you're paying the record companies to put on the records.

The other camp, including Audio-Technica and Stanton

TAKING CARE OF YOUR RECORDS

among others, believes that the benefits accruing from a thin lubricating film far outweigh any possible sonic degradation. In fact, they have lab tests that seem to prove the point.

How about user feedback? Judging from my own admittedly unscientific use of the products, it is difficult to take sides. I have lubricant-treated records that sound fine and have lasted through many plays, but I also have untreated ones in the same condition. I can think of at least two occasions when application of a lubricant caused sonic changes in the record, which, though minor, were noticeable. Try a few products and judge the results for yourself.

Needle cleaners

People seem to forget that a dirty needle means dirty sound. Nearly all the record machines I see come in with dust on the stylus. Maybe people are simply afraid to mess with such a delicate device. Maybe they just forget. But it is important to clean that needle, preferably after each side of the record.

One effective device is the SC-2 stylus cleaner from Discwasher. It comes with a special fluid designed to dissolve the combination of vinyl particles, dust and other contaminants that build up on a needle during play. A drop of fluid goes onto the brush, which is then slowly drawn from back to front across the stylus. Usually one pass is all that is required.

At first sight, the brush looks more like a stylus-ripper than cleaner because the bristles are very densely packed. But in years of use, I've never damaged a needle using one, and the effectiveness is unmatched by other things I've tried.

Another approach uses a small brush with loose bristles, which is dipped in a thick, almost jelly-like fluid. When brushed across the stylus, the fluid dissolves and removes contaminants. Presumably, it's easier on the needle than the densely packed SC-2.

Many inexpensive stylus cleaners are also available, but are best avoided. Most do nothing to remove the tiny contaminants that build up on the needle, and some actually cause damage. Chief among these is the inverted brush that mounts permanently on a changer base. As the arm cycles, the needle is dragged across the brush sideways, putting unacceptable lateral stress on the stylus cantilever. It violates the basic principle of stylus cleaning, that you always clean from back to front. Usually only the largest gobs of dust are removed, which should not have built up to begin with.

Cleaning old records

Until now, we have talked about preserving the fidelity of newly purchased records. What do you do about your favorite oldies? Once you have heard a properly maintained record, those dust-ridden old-timers are going to sound disappointing unless drastic steps are taken.

One obvious cleaning method is to put the record into a diluted solution of water and dishwashing detergent. Carefully rubbing the record with a soft cloth, in a circular motion, helps loosen the years of debris. Follow up with a good rinse, dry with a lint-free cloth and you're done. I've had good luck with this unsophisticated method. The trick is to be thorough in the cleaning and rinsing phase. Follow-up with an anti-static treatment. You may notice that the stylus picks up quite a bit of debris for the first few playings so clean it regularly. This method works well with popular music of limited dynamic range, but still leaves a little too much surface noise for full enjoyment of wide-range orchestral music.

The ultimate cleaner for old records is a jelly-like compound, usually composed of vinyl alcohol, which is brushed onto the record and left to dry, forming a thin layer of vinyl resembling plastic wrap. You then peel it off the record, presumably pulling dust particles and dirt from deep down in the groove. Empire Scientific used to market a product such as this, and it may still be available. Do-it-yourselfers may want to refer to Reg Williamson's article on record care in the April 1981 issue of *The Audio Amateur,* in which he describes a brew you can make at home.

Preserve and enjoy

If you are like me, all the rituals and procedures we have discussed may make playing records seem more trouble than it is worth. But, if you are willing to sacrifice a bit of fidelity for practicality, why not tape your records? Make copies while the records are still in pristine condition, then play the tape instead of the record. If the tape gets damaged, somewhere around its 50th play, you just re-record. Granted, a tape recording won't sound quite as good as the original, but compared to what the record will sound like after 50 plays, it is more than satisfactory.

Of course, you'll probably have to pretreat the record first, so don't run over to the tape deck just yet. Go out, get some potions, say your incantations and start treating those records. ES&T

Record care products

Nortronics

The Recorder Care Division of Nortronics Company, Minneapolis, has introduced its VCR maintenance kit. The kit provides an easy-to-use alternative to owners of portable VCRs manufactured by Matsushita Electronics. The new kit provides everything necessary for the owner to manually clean the VCRs video and audio heads as well as capstans and rollers.

The kit, VCR-96, contains a bottle of alcohol-free head cleaning solution; one reusable plastic wand; 11 soft, lint-free foam mittens, which fit over the wand; and a can of Super Blast compressed air duster. The suggested retail price for the kit is $14.95.

Most popular VCR drop-in cleaning cassettes will not work properly on VCRs using Matsushita's FP chassis because the tape tension sensing device is set to automatically shut the machine off if it senses more than 30 grams of tension on the supply or take-up motors.

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Circle (14) on Reply Card

Record care products

Nitty Gritty

Nitty Gritty, La Verne, CA has introduced two systems that make professional record cleaning available to a broad spectrum of home audio hobbyists. The Nitty Gritty II and III at $299 and $399, respectively, yield state-of-the-art record cleaning in two easy steps. Using the record platform provided for support, the user first scrubs the record with the special brush and fluid. Then, he flips the record over and vacuums it dry. The whole operation takes less than one minute, and the result is a clean and static-free disc.

The Nitty Gritty record vacuum forms the heart of the Nitty Gritty Record Cleaning System. All the action takes place on the top, with the turning, record platform and also the Teflon-covered hemicylindrical suction lips. These lips suction a path across the entire grooved surface, removing the particle-laden solvent.

A powerful vacuum motor is directly coupled to the lips. The spinning turbine in the top half of the motor is responsible for creating the air movement (or vacuum), and also vaporizing the fluid by its action, turning 22,000 revolutions per minute.

The special brush has microscopically fine bristles that do not clump up or go limp in the presence of large amounts of fluid.

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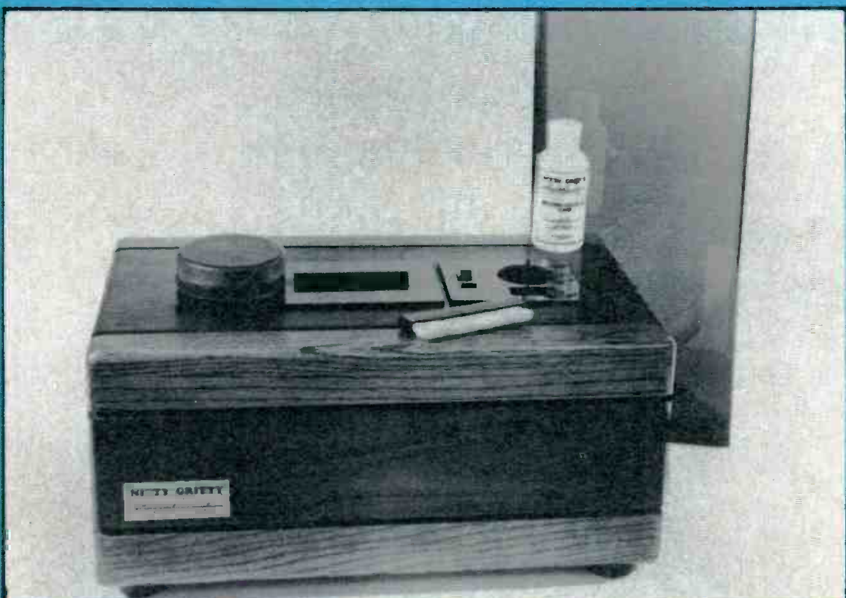

Allsop

Allsop, Bellingham, WA, has entered the record care market with the Allsop 3 Orbitrac record cleaning system.

Under development for more than two years, the Orbitrac uses a patented dual disk cleaning action that makes record cleaning simple.

The Orbitrac cleaning pad's ultra-soft fibers are aligned with record grooves when its pivot arm is placed into the record spindle hole.

The cleaning disk is attached via a precision internal bearing to a control disk. As the user spins the control disk around the record, the cleaning pad remains in perfect contact with the record grooves while the control disk pivots freely with the hand motions.

Orbitrac's ultra-soft fabric fibers lift dirt, dust and impurities from deep within record grooves. The cleaning disk surface is kept clean with a brush supplied with every Orbitrac. Allsop's Orbitrac system uses a specially formulated anti-static cleaning solution that has been tested for safety on all types of record vinyl including delicate imported virgin vinyl.

The Orbitrac comes complete with an attractively designed storage case, anti-static mat, convertible pivot point, solution spray dispenser bottle and pad cleaning brush. The product will retail for about $25.

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Allsop has also introduced a new, improved version of its audiocassette deck cleaner.

The Allsop 3 Ultraline cassette deck cleaner model 71300 uses a dual-gear-driven wiper arm, which cleans an area 50 percent larger than previous Allsop cleaners.

The dual-gear drive assures uniform performance even in three motor decks and decks with take-up reel sensors.

The unit's virgin wool felt pads are encased in precision-molded cartridges making replacement of the capstan, pinch roller and head cleaning felt pads quick and simple. The unit includes dual capstan

Benjamin Electroproducts

The Robins Division of Benjamin Electroproducts, Commack, NY, has introduced the audiocassette care kit model 25-010 which includes an audio tone electronic cassette head demagnetizer and a non-abrasive wet-type cleaning system. The demagnetizer removes magnetism from virtually all tape heads, and the wet system effectively cleans pinch rollers, capstans and heads. Both units work on any car, home or computer player/recorder.

The "Dust Magnet" silicone record cleaner model 41-000 uses a special tacky compound to reach deep into grooves and lift dust and particles. Dust may be washed off roller with water or alcohol.

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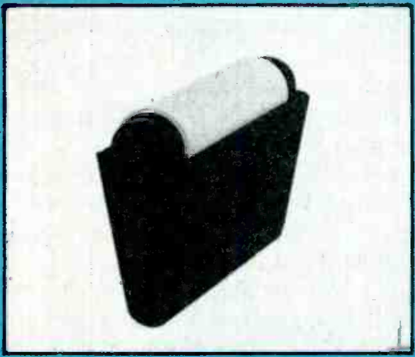

SSK Enterprises

Designed for use in all standard cassette mechanisms, the HCC-2001, from SSK Enterprises, Westlake Village, CA, uses continuously alternating wet/dry cleaning action to thoroughly clean the delicate magnetic recording head with a non-abrasive rotating cotton wheel. Being capstan driven, this wheel has a more uniform cleaning action and cannot jam like hub drive cleaners. By spring loading the head and capstan cleaning elements, positive cleaning action is assured, allowing the HCC-2001 cassette cleaner to be used in car, home and computer cassette mechanisms. Proper use of the HCC-2001 will ensure complete cleaning of the head, capstan and pinch roller, thereby, restoring the original performance of the record/playback head, and preventing expensive and annoying loss of tapes. The HCC-2001 retails for $7.95.

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Nagaoka

Nagaoka, Japan, has announced its intention to keep pace with the most recent advancement in sound reproduction, the Compact Disc. Although dust and fingerprints do not create the same background noise symptoms associated with analog discs, they instead can cause skipping and mistracking. Compact Disc Players are tested with a variety of obstacle course discs designed to simulate dust particles and fingerprints. The new Nagaoka CD cleaners are designed to remove dust and oil particles safely and effectively.

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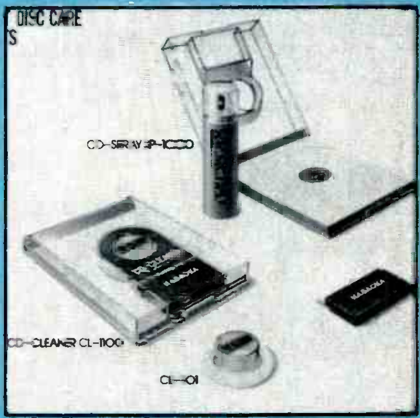

and pinch roller cleaning cartridges to automatically clean auto reverse decks and players.

All three cartridges, (head, two capstan and pinch roller) can be replaced in seconds using an insertion tool supplied with Allsop replacement cartridge kits.

Another feature is the use of two tensioned capstan and pinch roller pads in each cartridge. Cleaning of these two critical elements is enhanced by dedicating a separate pad to each element. The tensionalized capstan cleaner automatically adjusts the felt pad to clean capstans of different sizes.

Model 7100 cleaning system and case features the new gear-driven auto-reverse cleaner and also includes a larger supply of cleaning solution, a complete set of replacement cartridges with insertion tool, a supra leather carrying case and a home storage case. Suggested retail value for the Allsop 3 Ultraline model 71300 is $7.95 to $9.95. The Model 71200 Ultraline Cleaning System has a $14.95 to $16.95 value range.

The company has introduced the Allsop model 71010 replacement cartridge kit. The kit includes four pinch rollers and two head cleaner cartridges (enough for two complete replacements), a large bottle of Allsop cleaner and an insertion tool. Suggested retail value of the kit is $6.95 to $7.95.

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ES&T

(Continued from page 8)

the size of an LP covered with a sensitive layer in which a laser makes microscopically small pits. Depending on the basic material, a particular physical effect occurs during read-out by the laser so the information becomes available in coded form. The nature of the material determines whether digital data (alphanumeric information and digital audio) or video information can be stored. This depends on the required signal-to-noise ratio. The requirements for video in this respect are more difficult because of the large number of grey levels. For digital data (only two levels) things are much easier. The material also determines whether the information can be erased.

Optical recording obviously had much to offer, so an intensive search began for materials on which information could be stored with the aid of a laser. Philips research laboratories are currently studying three classes of material that seem suitable for the optical recording of information: tellurium-selenium alloys, organic compounds and magneto-optical materials. The last two groups are still almost completely at the research stage. Much more is known about tellurium alloys. Their present uses include the data disc for the digital optical recorder used in the Megadoc system that Philips has recently introduced.

Despite great differences between the new media for optical recording of information, there are a number of characteristic similarities in the recording and reproduction systems. Whichever disc is used, the system works best with a diode laser that operates in the infrared (about 88nm). This laser creates a physical change in the storage material (hole formation or a phase change in a tellurium-selenium alloy, pit formation in an organic compound or domain of the opposite magnetization direction in a magneto-optical material). All such areas have a cross-section of about 1 micron. The power of the laser for writing in information is about 10mW at a pulse length of 50ns. The read-out power is about 0.5mW for all materials.

Tellurium-selenium alloys

One of the new materials for information storage is a polycrystalline tellurium-selenium alloy, to which small quantities of other elements have been added. For example, arsenic gives better control of the melting point and the stability of the material. A thin layer of the alloy is applied to a substrate. A narrow laser beam melts this material locally so that holes are created with the same depth as the layer. During the read-out process, with a less intense laser beam, the presence or absence of holes produces differences in the reflection of the laser light. These differences in reflection represent the information in coded form.

Research has been concentrated on determining the composition of the alloy and on finding an efficient technique for applying a very thin layer of the alloy to a disc. The *shelf life* of the discs is extremely good. Life tests have shown that the stored information can be guaranteed for at least ten years without any need for special environmental conditions. Shelf life will be greatly increased in a controlled environment.

Signal-to-noise ratio that can be achieved is so high that the disc with a tellurium-selenium alloy is suitable for use as a storage medium for both digital data (alphanumeric information or digital audio) and video recording. The data disc for the digital optical recorder uses this technology.

The use of tellurium alloys also makes it possible to record information on a disc, erase it, and then use the disc again to record new information. By choosing the energy output of the laser appropriately (compared with the level necessary for the *hole* disc) the polycrystalline material is melted locally, but no holes are formed. After the laser pulse, the molten areas cool down so quickly that they solidify in a metastable amorphous phase. These amorphous domains reflect differently from the crystalline surroundings on read-out. Erasure takes place when a laser with a sufficiently high energy level transforms the amorphous domains into the crystalline phase.

In most applications, the disc can be used and erased many times. Storage of both digital data and video recording is possible because of the high signal-to-noise ratio. These materials for erasable storage are now at the transition stage between research and development.

Organic compounds

Organic dyes exist that absorb a great deal of light and have a high reflectance even when applied in thin layers. These thin layers of organic compounds seem to be a promising alternative to tellurium-selenium alloys. The memory effect is again obtained by melting the material locally with a laser to create small pits. A difference from the tellurium-selenium alloy is that these pits do not normally penetrate through to the substrate. The reflectance varies with the depth of the pit. The difference in reflection created by the pattern of pits is used when the information is being read.

This melting process is irreversible, so the disc can only be written once. The shelf life is good. It has been found that these organic compounds retain the information just as well as the *hole* discs with tellurium-selenium alloys. A great deal of research has been done on the *light-fastness* of the material, which ensures that its characteristic properties remain unchanged. These compounds have also been found to be resistant to heat and moisture. One attractive feature is the simple spin-coating process for applying the organic compound to the disc.

This type of disc has many applications. The signal-to-noise ratio obtained experimentally is high enough for the storage of both digital and video information.

Magneto-optical materials

Amorphous magnetic gadolinium-iron-cobalt compounds have been known for a long time. A laser can be used to heat the material locally, reverse the polarity of small areas and freeze it in this state. This technique makes it possible to write on a magnetized layer in a pattern of areas of opposite magnetization directions. This type of pattern can then be read out with polarized laser light. The direction of polarization of the reflected light is rotated slightly with respect to the polarization of the original laser beam as a result of the Kerr effect. The written areas on the disc can be distinguished from the unwritten ones, and information can be read out. Information can be erased just as easily as it is written. Areas to be erased are heated by the laser, while an external magnetic field is applied with the same direction as the original magnetization of the layer; the magnetization of the heated area reverts to its original direction after cooling. Information can be written, erased and rewritten as often as required.

Present research is concerned with the operational life of the stored information. The stability of the material is important here. At present the signal-to-noise ratio is only moderate, so this storage method is suitable for digital data only (alphanumeric information and digital audio signals). It could be possible to improve the signal-to-noise ratio sufficiently for the recording of video signals.

ES&T

Characteristics of Resistors

By Sam Wilson, CET

Most resistors, such as the carbon composition, flame-proof and wirewound types, are described as *linear, bilateral 2-terminal devices*. They are 2-terminal for the obvious reason that they have two leads. Bilateral simply means they conduct equally well in either direction.

Linear simply means that resistance remians the same regardless of the voltage or current, and so a plot of current vs. voltage would be a straight line. If you double the voltage across a linear resistor, then the current passing through it will also double. That assumes you are operating the resistor well within its power and temperature ratings.

If a carbon composition resistor is used in a location where the ambient temperature is high, then its nominal power rating is no longer valid. It must be derated in compliance with manufacturer's derating curves or charts. If those specifications are not available, then a simple equation can be used. If X is the temperature of the resistor location, then

Revised rating = Mfr's rating x [1 – (X-70)/80]

Example: A certain carbon composition resistor is rated at 1W. It is to be operated in a location where the temperature is 110°C. What is the power rating of the resistor in this location?

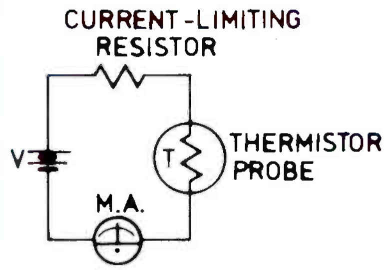

Figure 1

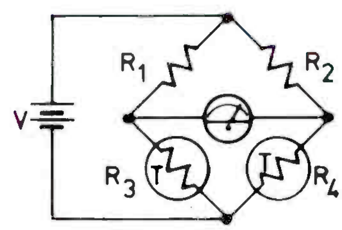

Figure 2

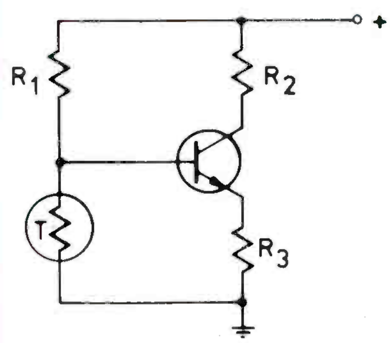

Figure 3

Solution:

Revised power rating = 1W x [1 – (110-70)/80] = ½W

You might not always have time to make calculations such as this, but it is interesting to see how ambient temperature affects the selection of a resistor's power rating. The message is clear– always replace resistors with the same power and resistance ratings.

Resistors operating in the presence of high-intensity electric fields may undergo changes that alter their characteristics. High-tension fields may even destroy the resistor even though it is operated within its power rating.

Non-linear resistors

A non-linear resistor does not conform to Ohm's law. If you double the voltage across a non-linear resistor, the current through it will *not* double.

The resistance of metals *increases* when temperature increases. However, the resistance of semiconductors and certain mixtures (such as nickel oxide) decreases with an increase in temperature.

A thermistor is an example of a resistor with a negative temperature coefficient; that is, its resistance decreases with an increase in temperature.

Heavily doped semiconductors act similar to metals, so they have a positive temperature Sensistor coefficient. A *Sensistor* is an example of a resistor with a positive temperature coefficient. (Sometimes they are called thermistors with a positive temperature coefficient.)

You *could* make a temperature probe with a thermistor by using a circuit such as the one shown in Figure 1. The milliammeter would be calibrated to indicate the temperature of the probe. As the probe temperature is increased, its resistance decreases, and the meter reads up scale.

The problem with the circuit in Figure 1 is that current flowing through the thermistor raises its temperature. Therefore, the probe resistance does not depend only upon the temperature being measured. Also, any change in battery voltage will change the temperature reading.

A better circuit is shown in Figure 2. With this bridge circuit, the same amount of current flows through the two thermistors. The balance of the bridge is not affected by current. Increasing the temperature of R_4 unbalances the bridge. The meter is calibrated to display temperature.

I once put a question about the circuit of Figure 2 in a prototype Industrial Electronics test. I was surprised by the number of people who thought the bridge amplifies the thermistor resistance change. Of course, there is no amplification in the circuit of Figure 2. There is, however, an increase in *sensitivity* because the thermistor probe resistance depends only upon the temperature being measured.

The *conduction* of a semiconductor increases as its temperature goes up. That means the emitter-base current increases with an increase in temperature. When the emitter-base current increases, the collector current also increases.

The thermistor in the circuit of Figure 3 stabilizes the circuit against changes in ambient temperature. When the temperature goes up, the transistor's emitter-base current would normally increase. However, the increase in temperature causes the resistance of the thermistor to decrease. The result is a lower base voltage at the junction of R_1 and the thermistor, so the base current is also decreased.

You will sometimes see it written that R_3 is a bias resistor. Its real purpose is to stabilize the amplifier against temperature changes. If an increase in temperature reduces the transistor resistance, the current through it and through R_3 rises. That makes the emitter more positive. It has the effect of *decreasing* the emitter-base bias current, so the transistor current is prevented from increasing.

Diodes as resistors

Diodes are usually used in applications where their non-linear, voltage-current characteristics can be used. However, the forward and reverse resistances of diodes can also be used in circuits. Figure 4 shows how the temperature/resistance characteristic is used to stabilize an amplifier against changes in ambient temperature. The forward resistance of D_1 and R_1 is used to pull down the base voltage to the proper forward bias value.

If the ambient temperature goes up, the emitter-base resistance decreases as mentioned before. The resistance of the diode will also decrease. The change in resistance will be similar for the diode and transistor if they are made with the same material. The base voltage is decreased by the lower diode resistance, and that prevents the emitter-base current of the transistor from increasing.

I once took a course in systems and was privileged to have one of the best instructors I ever met. Unfortunately, I've lost touch with him, but I've continued using his technique for analyzing circuits. He treated most circuits from the standpoint of resistance rather than current and voltage. I just gave one example with the diode in the base pull-down circuit.

As another example, Figure 5 shows a simple voltage regulator of the type sometimes found in integrated circuits. The voltage across the diodes is nearly constant despite changes in forward current.

Because V = IR, it is obvious that an increase in current must be accompanied by a decrease in resistance in order for V to be constant.

Suppose, for example, the current is doubled, making its value 2I. The resistance, then, must be

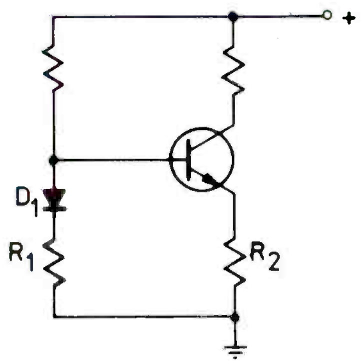

Figure 4

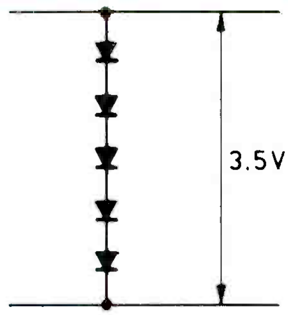

Figure 5

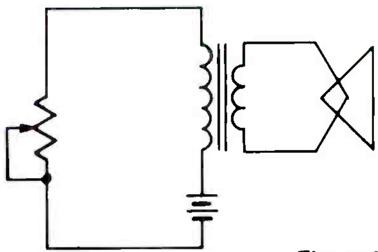
Figure 6

halved, making it R/2, so that V does not change:

$$V = I \times R = IR$$

The diode circuit can be thought of as being a variable resistor that automatically adjusts to keep the voltage constant.

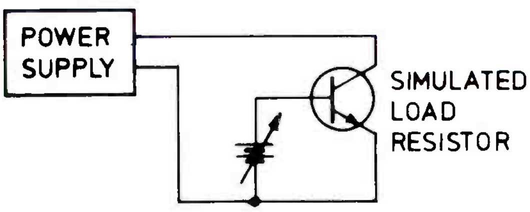

Figure 7

The transistor as a variable resistor

All of the 3-terminal amplifying devices (vacuum tubes, bipolar transistors and FETs) can be thought of as being variable resistors connected across a power supply. A good example is the audio power amplifier. A transistor example will be used here, but the concept works equally well with the other devices.

A power amplifier does not amplify power as its name implies. In reality, the power amplifier *controls* the amount of power delivered to a load of the power supply. In the case of the audio amplifier, the load is the speaker.

Suppose you connect a variable resistor as a rheostat in series with the load and the supply (see Figure 6). If the arm of the rheostat can be moved back and forth 1000 times per second, an audio tone will be heard in the speaker. The reason is that moving the arm causes the current to vary at that rate. This is actually what happens in a power amplifier circuit. Of course, the rheostat is replaced by the so-called power amplifier in the audio circuit. To summarize, the power amplifier can be thought of as being nothing more than a rheostat with the audio input *voltage* moving the arm of the rheostat back and forth.

Another good example of the power transistor being used as a variable resistor is in the simulated loads for power supplies and power amplifiers. By using a power transistor in those applications, it is possible to set the desired load simply by adjusting the base voltage (see Figure 7).

If you want to control an ac load you can use back-to-back transistors as simulated load resistors.

Voltage amplifiers can also be thought of as being variable resistors. In that case, the variable resistor is connected in series with a component that will produce an output *voltage* instead of current as in the case of the power amplifier.

The concept of analyzing circuits from the viewpoint of resistance will be extended as this series continues. ES&T

News

RCA to continue marketing discs

The RCA Videodisc Division will continue to actively market videodiscs to more than 550,000 owners of "CED" system players. RCA has announced that it plans to phase out the production of videodisc players this year because of continuing financial losses and narrowing prospects that the business would turn profitable.

Disc pressing operations are planned to continue at RCA's plant in Indianapolis for three years or as long as reasonable demand continues, according to Jack K. Sauter, RCA group vice president. The disc plant supplies products for the RCA, RCA-Columbia and other labels involved in the "CED" disc business.

As player production is phased down at RCA's TV receiver plant in Bloomington, IN, the RCA Videodisc Division "will begin a concentrated marketing effort, with specific support for dealers and distributors, to move more players and discs through retail," Sauter said.

FCC decision on TV stereo incorporates dbx system

The Federal Communications Commission (FCC) decision on TV stereo broadcasting protects the pilot tone for the EIA's BTSC system. The BTSC system consists of the dbx-TV noise reduction system and the Zenith transmission system, which had been selected by the EIA as the industry standard for TV stereo broadcasting.

"As we understand the FCC decision, it follows an 'open marketplace' rule. The commission, however, specifies that the first subcarrier can be used for stereo only and that other transmissions cannot interfere with the pilot tone for the EIA-selected system," according to Les Tyler, dbx vice president for engineering. The pilot tone is the transmitted signal that enables the TV receiver to switch to its TV stereo decoding circuitry. The concept is similar to that used for FM radio multiplex broadcasting.

"dbx is pleased that the FCC protected the pilot tone of the system recommended by the EIA. This standard was the calculation of five years' work in reviewing and testing various proposed systems," Tyler said. "The FCC, with its 'open marketplace' ruling, wisely allows marketplace pressure to exert influence for future improvements if new technology arises. Meanwhile, the EIA's BTSC system will be the prevailing standard."

ES&T

266 ready-to-build power

By Michael A. Covington

Low-voltage dc power supplies are among the most common circuits in all of electronics; all line-powered solid-state equipment contain them. Of the many possible power supply circuits, only three: the half-wave, full-wave bridge, and full-wave center-tapped configurations, are in wide use (Figure 1). The only things that vary are the specifications of the transformer and filter capacitor and, of course, the nature of the load.

Designing a power supply can be time consuming, especially because if you calculate that you need a 15.6V transformer and a 1650μF capacitor, you can't just specify these values in your parts list. You have to do the calculations a second time to find out if off-the-shelf components with values nearest the values you calculated (say, 18V and 1600μF) will give you acceptable output values. In this article I've done it all for you. The accompanying computer-generated tables cover all three circuit configurations with a wide variety of transformers and capacitors – 266 combinations in all. For each combination of transformer and capacitor, the table gives the dc voltage swing (from valley to peak of the ripple waveform), the ripple as a percentage of the average dc voltage, and the dc current.

Configurations and efficiency

The half-wave rectifier circuit is the easiest to build – it requires only one diode, and the transformer need not be tapped. But, it isn't very efficient. The transformer can only conduct when the diode is forward-biased, and this is only possible half of the time, when the ac voltage is swinging positive. Moreover, in order for the diode to

Half-wave power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
25.2	1.00	1000.	29.0 - 34.9	18.6	0.357
25.2	1.00	2200.	32.2 - 34.9	8.1	0.357
25.2	0.60	1000.	31.4 - 34.9	10.8	0.214
25.2	0.60	2200.	33.3 - 34.9	4.8	0.214
25.2	0.45	470.	29.2 - 34.9	17.8	0.161
25.2	0.45	1000.	32.3 - 34.9	8.0	0.161
25.2	0.45	2200.	33.7 - 34.9	3.5	0.161
25.2	0.20	220.	29.5 - 34.9	16.8	0.071
25.2	0.20	470.	32.4 - 34.9	7.5	0.071
25.2	0.20	1000.	33.7 - 34.9	3.5	0.071
25.2	0.20	2200.	34.4 - 34.9	1.6	0.071
25.2	0.10	100.	29.0 - 34.9	18.6	0.035
25.2	0.10	220.	32.2 - 34.9	8.1	0.035
25.2	0.10	470.	33.7 - 34.9	3.7	0.035
25.2	0.10	1000.	34.3 - 34.9	1.7	0.035
25.2	0.10	2200.	34.7 - 34.9	0.8	0.035
24.0	1.00	1000.	27.3 - 33.2	19.7	0.357
24.0	1.00	2200.	30.5 - 33.2	8.5	0.357
24.0	0.60	1000.	29.7 - 33.2	11.4	0.214
24.0	0.60	2200.	31.6 - 33.2	5.0	0.214
24.0	0.30	470.	29.4 - 33.2	12.1	0.107
24.0	0.30	1000.	31.5 - 33.2	5.5	0.107
24.0	0.30	2200.	32.4 - 33.2	2.5	0.107
24.0	0.20	220.	27.8 - 33.2	17.7	0.071
24.0	0.20	470.	30.7 - 33.2	7.9	0.071
24.0	0.20	1000.	32.1 - 33.2	3.6	0.071
24.0	0.20	2200.	32.7 - 33.2	1.6	0.071
24.0	0.10	100.	27.3 - 33.2	19.7	0.035
24.0	0.10	220.	30.5 - 33.2	8.5	0.035
24.0	0.10	470.	32.0 - 33.2	3.9	0.035
24.0	0.10	1000.	32.6 - 33.2	1.8	0.035
24.0	0.10	2200.	33.0 - 33.2	0.8	0.035
18.0	1.00	2200.	22.1 - 24.8	11.6	0.357
18.0	0.60	1000.	21.2 - 24.8	15.5	0.214

Power supply characteristics for off-the-shelf component values.

supply circuits

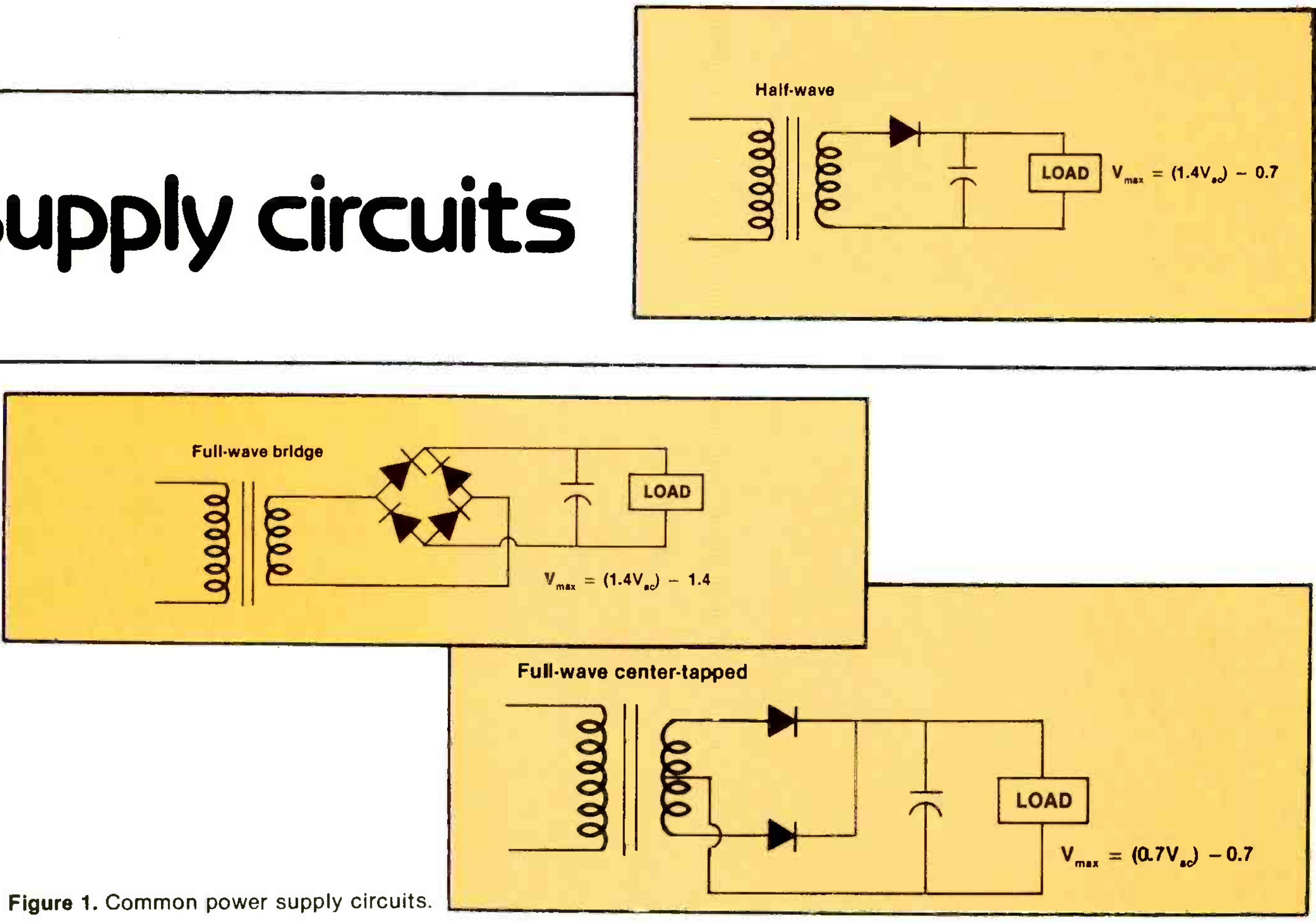

Figure 1. Common power supply circuits.

Symcures Wanted

Electronic Servicing and Technology

needs a broader variety of television Symcures. Especially needed are reports of Quasar, General Electric, Sylvania (or Philco), Sony Sears and Magnavox.

Symcures are, by definition, solutions to problems that have been encountered during the repair of *more than one* television set of the same make and model, and that may reasonably be expected to be a source of *recurrent* failure.

Please give the brand, model number, Photofact number, a brief description of the symptoms, a rough hand-drawn schematic of the area containing the defect, and a short description of the cure (including whether the defective component was open, leaky, shorted or intermittent).

ES&T editors will adapt the material to the Symcure format and have Photofact-style schematics prepared.

Send seven Symcures each time. Only six will be published, but the extra gives the editor a spare for one already printed in the past (or otherwise not suitable to the format). $30 will be paid for each page of six actually published (remember to include full name and address).

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Half-wave power supplies

Trans-former volts	Trans-former amps	Capaci-tance (mF)	DC voltage swing	Ripple (%)	DC amps
18.0	0.60	2200.	23.1 - 24.8	6.8	0.214
18.0	0.30	470.	21.0 - 24.8	16.6	0.107
18.0	0.30	1000.	23.0 - 24.8	7.5	0.107
18.0	0.30	2200.	23.9 - 24.8	3.3	0.107
18.0	0.20	470.	22.2 - 24.8	10.8	0.071
18.0	0.20	1000.	23.6 - 24.8	4.9	0.071
18.0	0.20	2200.	24.2 - 24.8	2.2	0.071
18.0	0.10	220.	22.1 - 24.8	11.6	0.035
18.0	0.10	470.	23.5 - 24.8	5.3	0.035
18.0	0.10	1000.	24.2 - 24.8	2.4	0.035
18.0	0.10	2200.	24.5 - 24.8	1.1	0.035
12.6	1.00	2200.	14.4 - 17.1	17.2	0.357
12.6	0.60	2200.	15.5 - 17.1	10.0	0.214
12.6	0.45	1000.	14.4 - 17.1	17.0	0.161
12.6	0.45	2200.	15.9 - 17.1	7.4	0.161
12.6	0.30	1000.	15.3 - 17.1	11.0	0.107
12.6	0.30	2200.	16.3 - 17.1	4.9	0.107
12.6	0.10	220.	14.4 - 17.1	17.2	0.035
12.6	0.10	470.	15.9 - 17.1	7.7	0.035
12.6	0.10	1000.	16.5 - 17.1	3.5	0.035
12.6	0.10	2200.	16.8 - 17.1	1.6	0.035
12.6	0.06	220.	15.5 - 17.1	10.0	0.021
12.6	0.06	470.	16.4 - 17.1	4.5	0.021
12.6	0.06	1000.	16.8 - 17.1	2.1	0.021
12.6	0.06	2200.	17.0 - 17.1	1.0	0.021
10.0	0.30	1000.	11.7 - 13.4	14.2	0.107
10.0	0.30	2200.	12.6 - 13.4	6.2	0.107
10.0	0.10	470.	12.2 - 13.4	9.9	0.035
10.0	0.10	1000.	12.8 - 13.4	4.5	0.035
10.0	0.10	2200.	13.2 - 13.4	2.0	0.035
6.3	0.60	2200.	6.6 - 8.2	21.9	0.214
6.3	0.30	2200.	7.4 - 8.2	10.4	0.107
6.3	0.20	1000.	7.0 - 8.2	15.6	0.071
6.3	0.20	2200.	7.7 - 8.2	6.8	0.071

Power supply characteristics for off-the-shelf component values.

conduct, the instantaneous ac voltage has to be higher than the charge on the capacitor, which means that conduction actually occurs in short, intense bursts rather than complete half-cycles.

As a result, the rms current through the transformer is much higher than the continuous dc current drawn by the load – about 2.8 times as high, to take a conservative estimate – and a 1A transformer can only provide 360mA of load current. Because of its inefficiency, the half-wave circuit is used only in relatively small power supplies.

An improvement is the full-wave bridge circuit, which achieves conduction on both half-cycles by using four diodes to "sort out" the incoming voltage and send it in the same direction each time, regardless of which way it is swinging. The result is greater efficiency; the transformer current rating need be only 2 times the required dc current.

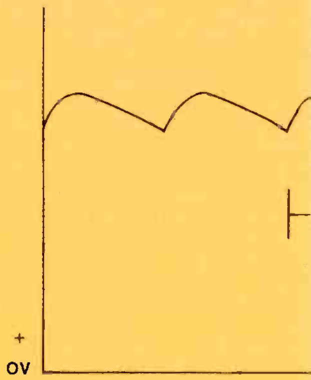


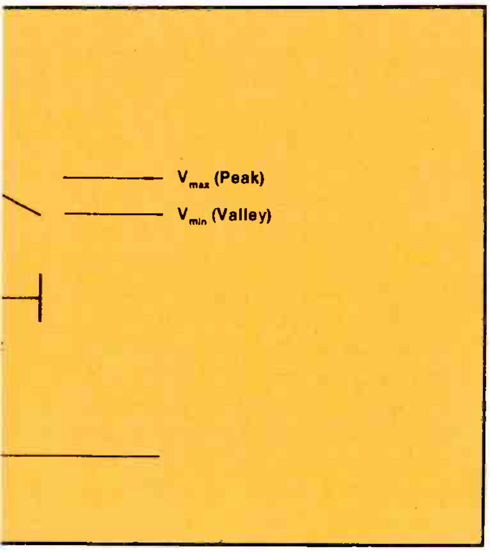
Figure 2. Ripple waveform.

However, the full-wave center-tapped circuit is still better. Not only does it charge the capacitor on both positive and negative half cycles, but it uses each half of the transformer only half of the time. Because the duty cycle of any part of the transformer winding is only 50 percent, the effective current through the transformer is only half what it would otherwise have been. As a result, the transformer current rating can be equal to the dc load current, or even slightly less.

Because of the superiority of the center-tapped circuit for high-current applications, the table dealing with it covers a wider range of transformers and capacitors than the other two tables.

Ripple

The dc that comes out of these power supply circuits contains a small amount of residual ac called *ripple* (Figure 2). The amount of



Full-wave bridge power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
25.2	1.00	1000.	30.1 - 34.2	13.0	0.500
25.2	1.00	2200.	32.3 - 34.2	5.7	0.500
25.2	0.60	470.	28.9 - 34.2	16.8	0.300
25.2	0.60	1000.	31.7 - 34.2	7.6	0.300
25.2	0.60	2200.	33.1 - 34.2	3.4	0.300
25.2	0.45	470.	30.2 - 34.2	12.4	0.225
25.2	0.45	1000.	32.4 - 34.2	5.6	0.225
25.2	0.45	2200.	33.4 - 34.2	2.5	0.225
25.2	0.20	220.	30.5 - 34.2	11.7	0.100
25.2	0.20	470.	32.5 - 34.2	5.3	0.100
25.2	0.20	1000.	33.4 - 34.2	2.5	0.100
25.2	0.20	2200.	33.9 - 34.2	1.1	0.100
25.2	0.10	100.	30.1 - 34.2	13.0	0.050
25.2	0.10	220.	32.3 - 34.2	5.7	0.050
25.2	0.10	470.	33.4 - 34.2	2.6	0.050
25.2	0.10	1000.	33.8 - 34.2	1.2	0.050
25.2	0.10	2200.	34.0 - 34.2	0.6	0.050
24.0	1.00	1000.	28.4 - 32.5	13.7	0.500
24.0	1.00	2200.	30.6 - 32.5	6.0	0.500
24.0	0.60	470.	27.2 - 32.5	17.8	0.300
24.0	0.60	1000.	30.0 - 32.5	8.0	0.300
24.0	0.60	2200.	31.4 - 32.5	3.6	0.300
24.0	0.30	220.	26.9 - 32.5	19.1	0.150
24.0	0.30	470.	29.9 - 32.5	8.5	0.150
24.0	0.30	1000.	31.3 - 32.5	3.9	0.150
24.0	0.30	2200.	32.0 - 32.5	1.8	0.150
24.0	0.20	220.	28.8 - 32.5	12.4	0.100
24.0	0.20	470.	30.8 - 32.5	5.6	0.100
24.0	0.20	1000.	31.7 - 32.5	2.6	0.100
24.0	0.20	2200.	32.2 - 32.5	1.2	0.100
24.0	0.10	100.	28.4 - 32.5	13.7	0.050
24.0	0.10	220.	30.6 - 32.5	6.0	0.050
24.0	0.10	470.	31.7 - 32.5	2.8	0.050
24.0	0.10	1000.	32.1 - 32.5	1.3	0.050
24.0	0.10	2200.	32.4 - 32.5	0.6	0.050
18.0	1.00	1000.	19.9 - 24.1	19.0	0.500
18.0	1.00	2200.	22.2 - 24.1	8.2	0.500
18.0	0.60	1000.	21.6 - 24.1	11.0	0.300
18.0	0.60	2200.	22.9 - 24.1	4.8	0.300
18.0	0.30	470.	21.4 - 24.1	11.7	0.150
18.0	0.30	1000.	22.8 - 24.1	5.3	0.150

Full-wave bridge power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
18.0	0.30	2200.	23.5 – 24.1	2.4	0.150
18.0	0.20	220.	20.3 – 24.1	17.1	0.100
18.0	0.20	470.	22.3 – 24.1	7.7	0.100
18.0	0.20	1000.	23.2 – 24.1	3.5	0.100
18.0	0.20	2200.	23.7 – 24.1	1.6	0.100
18.0	0.10	100.	19.9 – 24.1	19.0	0.050
18.0	0.10	220.	22.2 – 24.1	8.2	0.050
18.0	0.10	470.	23.2 – 24.1	3.8	0.050
18.0	0.10	1000.	23.6 – 24.1	1.7	0.050
18.0	0.10	2200.	23.9 – 24.1	0.8	0.050
12.6	1.00	2200.	14.5 – 16.4	12.2	0.500
12.6	0.60	1000.	13.9 – 16.4	16.5	0.300
12.6	0.60	2200.	15.3 – 16.4	7.2	0.300
12.6	0.45	1000.	14.5 – 16.4	12.1	0.225
12.6	0.45	2200.	15.6 – 16.4	5.3	0.225
12.6	0.30	470.	13.8 – 16.4	17.6	0.150
12.6	0.30	1000.	15.2 – 16.4	7.9	0.150
12.6	0.30	2200.	15.9 – 16.4	3.5	0.150
12.6	0.10	220.	14.5 – 16.4	12.2	0.050
12.6	0.10	470.	15.5 – 16.4	5.5	0.050
12.6	0.10	1000.	16.0 – 16.4	2.6	0.050
12.6	0.10	2200.	16.2 – 16.4	1.2	0.050
12.6	0.06	100.	13.9 – 16.4	16.5	0.030
12.6	0.06	220.	15.3 – 16.4	7.2	0.030
12.6	0.06	470.	15.9 – 16.4	3.3	0.030
12.6	0.06	1000.	16.2 – 16.4	1.5	0.030
12.6	0.06	2200.	16.3 – 16.4	0.7	0.030
10.0	1.00	2200.	10.8 – 12.7	16.1	0.500
10.0	0.30	1000.	11.5 – 12.7	10.3	0.150
10.0	0.30	2200.	12.2 – 12.7	4.6	0.150
10.0	0.10	220.	10.8 – 12.7	16.1	0.050
10.0	0.10	470.	11.9 – 12.7	7.2	0.050
10.0	0.10	1000.	12.3 – 12.7	3.3	0.050
10.0	0.10	2200.	12.6 – 12.7	1.5	0.050
6.3	0.60	2200.	6.4 – 7.5	16.4	0.300
6.3	0.30	1000.	6.3 – 7.5	18.2	0.150
6.3	0.30	2200.	6.9 – 7.5	7.9	0.150
6.3	0.20	1000.	6.7 – 7.5	11.7	0.100
6.3	0.20	2200.	7.1 – 7.5	5.2	0.100

Power supply characteristics for off-the-shelf component values.

ripple is an important factor in power supply design; the tables accompanying this article give the voltage swing (minimum to maximum) and the ripple as a percentage of the average output voltage, all assuming that the power supply is carrying the full rated dc load.

Normally, the output of the power supply is fed into a voltage regulator to remove ripple almost entirely. In this case the voltage coming out of the power supply must not swing below the minimum input voltage of the voltage regulator (7V, for example, for the popular type 7805 5+V regulator IC). Therefore, the minimum voltage is the one that counts.

The formula for calculating ripple is:

$$\text{Ripple (peak-to-peak)} + = I_{dc}/(FC)$$

where F is the frequency of the charging pulses, C is the filter capacitance in farads, and I_{dc} is the dc load current in amps.

From the formula you can deduce a number of convenient rules of thumb:

(1) The ripple is proportional to the load current. Cut the load current in half and you cut the ripple in half (the maximum, or peak, voltage remains the same, and the minimum voltage moves closer to it). Remove the load entirely, and the ripple disappears. (This means that you can not test a power supply for ripple with the load disconnected!)

Full-wave center-tapped power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
24.0	2.00	10000.	14.6 - 16.3	10.8	2.00
24.0	1.50	4700.	13.6 - 16.3	17.8	1.50
24.0	1.50	6400.	14.3 - 16.3	12.8	1.50
24.0	1.50	10000.	15.0 - 16.3	8.0	1.50
24.0	1.00	4700.	14.5 - 16.3	11.5	1.00
24.0	1.00	6400.	15.0 - 16.3	8.3	1.00
24.0	1.00	10000.	15.4 - 16.3	5.3	1.00
24.0	0.60	2200.	14.0 - 16.3	15.0	0.60
24.0	0.60	4700.	15.2 - 16.3	6.8	0.60
24.0	0.60	6400.	15.5 - 16.3	4.9	0.60
24.0	0.60	10000.	15.8 - 16.3	3.1	0.60
24.0	0.30	1000.	13.8 - 16.3	16.6	0.30
24.0	0.30	2200.	15.1 - 16.3	7.2	0.30
24.0	0.30	4700.	15.7 - 16.3	3.3	0.30
24.0	0.30	6400.	15.9 - 16.3	2.4	0.30
24.0	0.30	10000.	16.0 - 16.3	1.5	0.30
25.2	2.00	6400.	14.5 - 17.1	16.5	2.00
25.2	2.00	10000.	15.5 - 17.1	10.2	2.00
25.2	1.00	4700.	15.3 - 17.1	10.9	1.00
25.2	1.00	6400.	15.8 - 17.1	7.9	1.00
25.2	1.00	10000.	16.3 - 17.1	5.0	1.00
25.2	0.60	2200.	14.8 - 17.1	14.2	0.60
25.2	0.60	4700.	16.1 - 17.1	6.4	0.60
25.2	0.60	6400.	16.3 - 17.1	4.7	0.60
25.2	0.60	10000.	16.6 - 17.1	3.0	0.60
25.2	0.45	2200.	15.4 - 17.1	10.5	0.45
25.2	0.45	4700.	16.3 - 17.1	4.8	0.45
25.2	0.45	6400.	16.5 - 17.1	3.5	0.45
25.2	0.45	10000.	16.7 - 17.1	2.2	0.45
25.2	0.20	1000.	15.5 - 17.1	10.2	0.20
25.2	0.20	2200.	16.4 - 17.1	4.5	0.20
25.2	0.20	4700.	16.8 - 17.1	2.1	0.20
25.2	0.20	6400.	16.9 - 17.1	1.5	0.20
25.2	0.20	10000.	17.0 - 17.1	1.0	0.20
25.2	0.10	470.	15.3 - 17.1	10.9	0.10
25.2	0.10	1000.	16.3 - 17.1	5.0	0.10
25.2	0.10	2200.	16.7 - 17.1	2.2	0.10
25.2	0.10	4700.	16.9 - 17.1	1.0	0.10
25.2	0.10	6400.	17.0 - 17.1	0.8	0.10
25.2	0.10	10000.	17.0 - 17.1	0.5	0.10
24.0	2.00	6400.	13.7 - 16.3	17.4	2.00

Full-wave center-tapped power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
24.0	0.20	1000.	14.6 - 16.3	10.8	0.20
24.0	0.20	2200.	15.5 - 16.3	4.8	0.20
24.0	0.20	4700.	15.9 - 16.3	2.2	0.20
24.0	0.20	6400.	16.0 - 16.3	1.6	0.20
24.0	0.20	10000.	16.1 - 16.3	1.0	0.20
24.0	0.10	470.	14.5 - 16.3	11.5	0.10
24.0	0.10	1000.	15.4 - 16.3	5.3	0.10
24.0	0.10	2200.	15.9 - 16.3	2.4	0.10
24.0	0.10	4700.	16.1 - 16.3	1.1	0.10
24.0	0.10	6400.	16.1 - 16.3	0.8	0.10
24.0	0.10	10000.	16.2 - 16.3	0.5	0.10
18.0	2.00	10000.	10.4 - 12.0	14.9	2.00
18.0	1.50	6400.	10.1 - 12.0	17.7	1.50
18.0	1.50	10000.	10.8 - 12.0	11.0	1.50
18.0	1.00	4700.	10.3 - 12.0	15.9	1.00
18.0	1.00	6400.	10.7 - 12.0	11.4	1.00
18.0	1.00	10000.	11.2 - 12.0	7.2	1.00
18.0	0.60	2200.	9.8 - 12.0	20.9	0.60
18.0	0.60	4700.	11.0 - 12.0	9.3	0.60
18.0	0.60	6400.	11.2 - 12.0	6.7	0.60
18.0	0.60	10000.	11.5 - 12.0	4.2	0.60
18.0	0.30	2200.	10.9 - 12.0	9.9	0.30
18.0	0.30	4700.	11.5 - 12.0	4.5	0.30
18.0	0.30	6400.	11.6 - 12.0	3.3	0.30
18.0	0.30	10000.	11.8 - 12.0	2.1	0.30
18.0	0.20	1000.	10.4 - 12.0	14.9	0.20
18.0	0.20	2200.	11.3 - 12.0	6.5	0.20
18.0	0.20	4700.	11.7 - 12.0	3.0	0.20
18.0	0.20	6400.	11.8 - 12.0	2.2	0.20
18.0	0.20	10000.	11.9 - 12.0	1.4	0.20
18.0	0.10	470.	10.3 - 12.0	15.9	0.10
18.0	0.10	1000.	11.2 - 12.0	7.2	0.10
18.0	0.10	2200.	11.6 - 12.0	3.2	0.10
18.0	0.10	4700.	11.9 - 12.0	1.5	0.10
18.0	0.10	6400.	11.9 - 12.0	1.1	0.10
18.0	0.10	10000.	11.9 - 12.0	0.7	0.10
12.6	1.50	10000.	7.0 - 8.2	16.5	1.50
12.6	1.00	6400.	6.9 - 8.2	17.2	1.00
12.6	1.00	10000.	7.4 - 8.2	10.7	1.00
12.6	0.60	4700.	7.1 - 8.2	13.9	0.60
12.6	0.60	6400.	7.4 - 8.2	10.0	0.60

Power supply characteristics for off-the-shelf component values.

(2) The ripple is inversely proportional to the frequency. Therefore, full-wave configurations, which charge 120 times a second, have only half as much ripple as half-wave circuits with the same capacitance and load current.

(3) The ripple is inversely proportional to the capacitance. Double the capacitance and you cut the ripple in half.

Transformer characteristics

The rated voltage of a transformer is the voltage it delivers under full load. The voltage under no load is typically 15 percent higher for power transformers, or as much as 50 percent higher for small plug-in wall transformers. This should be taken into account when an unregulated power supply is connected to something that would be damaged by too high a voltage.

The calculations in the tables assume that the resistance of the transformer secondary is small. A transformer secondary with appreciable resistance has some advantages. The voltage drop does, of course, cause the voltage to vary with load current, but the resistance puts a limit on the intensity of the charging pulses, reducing ripple and allowing a transformer with a given current rating to carry a heavier dc load. So, if you come across a commercially built power supply that, according to the tables, ought not to work, don't lose your faith in the equations presented here. The transformer winding resistance may have been figured in. ES&T

Full-wave center-tapped power supplies

Transformer volts	Transformer amps	Capacitance (mF)	DC voltage swing	Ripple (%)	DC amps
12.6	0.60	10000.	7.7 - 8.2	6.3	0.60
12.6	0.45	4700.	7.4 - 8.2	10.2	0.45
12.6	0.45	6400.	7.6 - 8.2	7.4	0.45
12.6	0.45	10000.	7.8 - 8.2	4.7	0.45
12.6	0.30	2200.	7.1 - 8.2	14.9	0.30
12.6	0.30	4700.	7.7 - 8.2	6.7	0.30
12.6	0.30	6400.	7.8 - 8.2	4.9	0.30
12.6	0.30	10000.	8.0 - 8.2	3.1	0.30
12.6	0.10	1000.	7.4 - 8.2	10.7	0.10
12.6	0.10	2200.	7.8 - 8.2	4.7	0.10
12.6	0.10	4700.	8.0 - 8.2	2.2	0.10
12.6	0.10	6400.	8.1 - 8.2	1.6	0.10
12.6	0.10	10000.	8.1 - 8.2	1.0	0.10
12.6	0.06	470.	7.1 - 8.2	13.9	0.06
12.6	0.06	1000.	7.7 - 8.2	6.3	0.06
12.6	0.06	2200.	8.0 - 8.2	2.8	0.06
12.6	0.06	4700.	8.1 - 8.2	1.3	0.06
12.6	0.06	6400.	8.1 - 8.2	1.0	0.06
12.6	0.06	10000.	8.2 - 8.2	0.6	0.06
10.0	1.00	10000.	5.5 - 6.4	14.0	1.00
10.0	0.30	2200.	5.2 - 6.4	19.6	0.30
10.0	0.30	4700.	5.8 - 6.4	8.7	0.30
10.0	0.30	6400.	6.0 - 6.4	6.3	0.30
10.0	0.30	10000.	6.1 - 6.4	4.0	0.30
10.0	0.10	1000.	5.5 - 6.4	14.0	0.10
10.0	0.10	2200.	6.0 - 6.4	6.1	0.10
10.0	0.10	4700.	6.2 - 6.4	2.8	0.10
10.0	0.10	6400.	6.2 - 6.4	2.1	0.10
10.0	0.10	10000.	6.3 - 6.4	1.3	0.10
6.3	0.60	10000.	3.3 - 3.8	14.3	0.60
6.3	0.30	4700.	3.2 - 3.8	15.2	0.30
6.3	0.30	6400.	3.4 - 3.8	11.0	0.30
6.3	0.30	10000.	3.5 - 3.8	6.9	0.30
6.3	0.20	4700.	3.4 - 3.8	9.9	0.20
6.3	0.20	6400.	3.5 - 3.8	7.2	0.20
6.3	0.20	10000.	3.6 - 3.8	4.5	0.20

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Readers' Exchange

For sale: Heathkit solid-state, 5-inch oscilloscope, model 10-102, in good condition with probe and manual, $40 plus shipping, or send money order for $50 total. *B.H. Mineer, P.O. Box 379, South Portsmouth, KY 41174.*

For sale: Used flybacks, yokes and triplers for color TV, any item for $12. Send SASE for complete list. Also, Tektronix oscilloscope, RM16, $150; Hewlett-Packard oscillators, 200CD, 202C and 202A, $35 each. Includes UPS on all items. *Fred Jones, 407 Morningbird Court, Niceville, FL 32578.*

For sale: GE 16CWP4, good CRT condition, also GE yoke ES 76X48, reasonable price. *Jiranek TV, Farmington, IA 52626.*

Needed: Service manuals for the JVC model JR-S61W stereo receiver/amp; Panasonic RS-876AS stereo cassette; Telex C6220 console stereo. *Pax-Tronix Corporation, Great Mills Road, Route 4, Box 447H, Lexington Park, MD 20653; 301-863-5084.*

Wanted: Sencore VA48 video analyst in good condition (desperately needed). Will pay $700 plus C.O.D. shipping. Also want Sams' Photofact auto radio volumes, prefer 1970 to present (will buy single or multiple volumes). *Dawn Williams, 1033 W. Standley St., Ukiah, CA 95482; 707-468-5730.*

For sale: Heath model 2264 digital multimeter, plus extras. Assembled and tested, never used. *Farrel Becnel, Route 3, Box 3, River Road, Luling, LA 70070.*

For sale: Sencore Super Mack CR31A CRT tester, with many additional sockets; Sencore Porta-Pak Supply PS-43; and B&K 1500, 100MHz, 4-channel scope. All equipment in excellent condition with probes and manuals. Best offer. *Al Avadian, 2211 S. 10th St., Milwaukee, WI 53215; 414-643-7985.*

For sale: FC45 frequency counter, $350; B&K 820 capacitance meter, $75; Eico 633 CRT tester with adaptors, $100. UPS included. *Bill Bechtold, 7429 Frederick, Omaha, NE 68124; 402-397-2461.*

Needed: Sams MHF-HTP or TR manuals and/or compilations of manufacturers' service literature covering Hi-Fi (amps, tuners, cassette decks, etc.) Nothing over two years back, please. *Bryce Hayward, 2407 Guess Road, Durham, NC 27705.*

For sale: Old radios, tubes, parts, manuals (Riders' book 23 missing), RCA (1923-1952) how-to books, much reference material. Will consider trade. *Frank Ingrassia, 15467 Monterey Lane, Kerman, CA 93630; 209-846-6516.*

Needed: Schematic, parts layout, or any information on Lake model 4101 AM-FM stereo and 8-track tape player will be greatly appreciated. *Jim Garrison, 171 Cornwell Drive, Bridgeton, NJ 08302.*

For sale: Supreme service manuals R-1 through 27, AU-1, TV-1 through 29 (except TV-19), C-69, C-70, UHF-1 and master index. Prepaid UPS to any U.S. address for $200. *C.E. Maupin, 2124 S.W. 68, Oklahoma City, OK 73159.*

Needed: Audio output transformer and schematic for Ace tone 160W channel mixer musical amplifier, model #VM-80, or current address of manufacturer, Ace Electronic Industries, Inc. *William M. Suhy, 456 Burritt Ave., Stratford, CT 06497; 203-238-8888.*

For sale: VA48 Sencore TV-VTR-MATV and video analyzer, excellent condition with leads and manual, $800. *George Wenzel, 3417 Graceland Ave., Madison, WI 53704; 608-249-3181.*

For sale: Non-linear portable oscilloscope, model MS-215, 15MHz, dual trace, probes and book, only used 6 months, rechargeable batteries, $299. *Bill Spiegel, 1639 Nash Ave., Pittsburgh, PA 15235; 412-795-3094.*

For sale: B&K 1077B TV analyst in original carton, used one time, $300; B&K 415 alignment generator, $150; and RCA 535A oscilloscope, new in original carton, $300. *Ralph Dorough, 117 Pecan St., Terrell, TX 75160; 214-563-7105.*

Needed: Sylvania model CL829P-2, 25-inch color TV schematics, or ET 1971 February issue, chassis D1220, Sams 1185. *John L. Szeghalmi, 1120 N.E. 200th St., N. Miami Beach, FL 33179.*

Needed: Small color bar generator, Heathkit IG-5240 or similar Eico, Hickok, etc. *Ed Herbert, 410 N. Third, Minersville, PA 17954.*

For sale: 73 black and white picture tubes, 12-inch to 24-inch, all boxed and new or rebuilt, no "pulls," $200. Send SASE for list. *Charles Paige, 8 Cedar Grove Ave., Peabody, MA 01960.*

For sale: Sencore VA48 video analyzer, $750; B&K 1474 scope, $425; B&K 3010 function generator, $100. All like new with manuals and cables. Other TV test equipment. *D.G. Piacentini, 12 Joyce Road, Plainview, L.I., NY 11803.*

For sale: Sencore Micro Rauger DVM 56, $500; B&K 415 sweep marker generator, $300; Sencore YF33 Ringer, $125, like new.*Paulmer Williams, 112 S. Jefferson St., Lewisburg, WV 24901. 304-647-5414.*

For sale: Sencore SC60 dual trig. scope with test leads and instructions, good condition, $950. *Val Obal, 3201 S. 73rd St., Omaha, NE 68124; 402-393-0459.*

Wanted: All test data settings for all the types of voltage regulator tubes that can be tested on a Precision tube tester model 912P, will pay price. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

For sale: Scope 5-inch Heathkit by Daystron, model 10-10, $100; Eico multisignal tracer, model 145, $25; B&K analyst model 1075, $75. All plus postage, U.S. money order. *E. Barlow, P.O. Box 29, Tweed, Ontario, Canada K0K 3J0.*

Needed: Schematic and/or component information on 1970 Ross (later Morse Electrophonics) model 8801 AM/FM stereo radio, 8-track tape player. Will buy or copy and return. *William Biederman, Route 1, Chelsea Road, Wappingers Falls, NY 12590.*

For sale: Sencore VA48 video analyzer with all cords and options, 1 year old, $750; Conar 281 signal generator and Eico 944 flyback/yoke tester. Make offer on any or all equipment. *Andrew K. Oberg, 2111 N. St. Louis, Joplin, MO 64801; 417-781-8619.*

Needed: Sams Quickfact #5901, Magnavox. *Ernest F. Meade, 502 1st Ave., West Logan, WV 25601.*

For sale: Tektronix scope type 536 with wide band differential calibrated preamp and time base generator, $100; Heath frequency counter model IM4110, $100; and Leader color bar generator, model LCC384, $75. *A. Bartolotta, 28-C Rosilia Lane, Fishkill, NY 12524; 914-896-7551.*

Needed: Heath IG-5237 FM stereo generator in good condition with manuals. *Bob Kramer, 919 Grove St., Aurora, IL 60505; 312-898-8946.*

For sale: Heathkit IG57A TV post marker sweep generator, $125; Sencore color bar generator CG 138, $50; Sencore Little Huey color bar generator CG25, $75. Will ship UPS collect. *Richard Rhiver, 6 Schuyler Place, Bayonne, NJ 07002.*

Needed: Latest available test settings for a Jackson model 598 tube tester. Will pay expenses or cost. If not available, then will purchase a tube tester, with current tube test settings, at a reasonable cost. *W. Muller, 7454 Knob Hill, Pasadena, TX 77505.*

For sale: Sencore model SS137 sweep circuit analyzer, $120, in mint condition. In-circuit tests flybacks, yokes, horizontal and vertical oscillators, especially suited for tube-type color and b&w sets. Measures dc voltages 0-1000V, 10KV (focus) and 30KV (high voltage). Complete with 4 test leads, HV probe and complete instructions. Will ship UPS collect. *C.A. Caputo, 7 Donna St., Peabody, MA 01960; 617-535-1091.*

For sale: Siltronix 1011C transceiver, Siltronix model 90 VFO, HyGain 674 AM/SSB transceiver with VFO. All in good condition and operation, best offer. *M. Moorman, P.O. Box 2923, Greenville, NC 27834; 919-756-0004.*

Needed: Digital synthesizer 16-pin chip for a Johnson C.B. 242-4140. 242-4145. The numbers on the chip are NS/645 3001-201, on the schematic, type SC42502P, MFG #544-3001-201, information on source of supply or a substitute chip would be greatly appreciated. Will pay for information. *Clarence H. Moritz, P.O. Box 128, Edina, MO 63537; 816-397-2667.*

For sale: Sencore VA48 video analyzer, like new, $795; Sencore CR143 CRT tester, $95; 300 Sams 1000-2000 with 4-drawer file, $495. Send SASE for details. *Harley W. Jansen, 1600 1st Ave., Marion, IA 52302; 319-377-3141.*

Needed: CRT for Sony TV 470BEBP22. Prefer used tube, state price by return letter. *Davis Electronic Center, 210 W. 5th St., Lexington, KY 40508.*

Needed: Schematic and service manual for Elgin (by JVC) model RM-4320 AM/FM/8-track stereo. Will purchase copy or original or will copy and return. *J. McKenzie, Box 33, Wonewoc, WI 53968.*

For sale: Sencore model SG-165 AM/FM stereo analyzer, $500. B&K model 290 solid-state electronic multimeter including a PR-32 demodulator probe and a PR-28 high-voltage multiplier probe; $150. B&K model 1820 80MHz frequency counter including a SA-10 signal tap; $150. All equipment is like new with accessories and instruction manuals. *Clarence G. Mckee, 9516 Zion Road, Rives Junction, MI 49277; 517-569-3139.*

For sale: Sams Photofact intermittent sequence 37 to 277, 34 volumes, 1975 to 1979 Delco; service manuals (five volumes), $2.25 each. *Richard E. Wood, Box 338 Lenn Road, Newburgh, IN 47630.*

Needed: Schematic and owner's manual for Wilson WE-800 transmitter receiver. Will buy manual or pay for reproduction cost. *Ken Johnson, 506 Harvey Drive, Racine, WI 53405; 414-637-5019.*

For sale: Simpson model DM461 digital voltmeter with adapter, nicads, $115. Sams Photofact numbers 66 to 1185, with four filing cabinets; $1000. Sencore transistor checker, model TR139; $69. *Mike Terrick, Terrick TV, 809 Amity St., Homestead, PA 15120; 412-462-8720.*

For sale: Elco model 460 scope, good working condition. $100 plus $10 for shipping. *Gad Barzily, 84-39 120th St., Kew Gardens, NY 11415.*

Needed: Manual/schematic for a B&K 1077B TV analyst. Will copy and return or purchase. *David O'Blenes, Route 8, Box 287F, Gainesville, GA 30501.*

For sale: Electronic Technician schematics from Oct. 1965 to Dec. 1977, $25 plus shipping. *Jerome Stanisz, 163 Richard Ave., Elmhurst, IL 60126.*

Needed: Diagram of a Lloyd's 8-track stereo model 2m75w-07a. *Lynn Weigle, Lynn's TV & Electronics, 6805 Forest Court, Des Moines, IA 50311.*

Needed: Documentation schematics, operating manual and any other available service information on the Hazeltine H2000A video terminal. *Samuel Pearlman, 25 Wolcott Road, Lynn, MA 01902; 617-598-0610.*

Wanted: Schematic or service manual for B&K model 970 transistor analyst and Intellivision video game model 2609. *Glaser's TV Service, Box 116, Bruno, Sask., Canada S0K 0S0.*

For sale: Sencore CA 55 capacitor analyzer, mint condition. $400. *Daniel C. Lee, P.O. Box 42, Osakis, MN 56360; 612-859-2851.*

Needed: Schematic for ADX model 5000 bass frequency mixer bass guitar amplifier. *McPherson Electronics, 1219 S. College Ave.; Dixon, IL 61021.*

For sale: B&K analyst model 1077B. Will ship. $300. *Al Rosa, 650 Daphne St., Broomfield, CO 80020; 303-466-6798.*

Needed: Schematic for Stromberg-Carlson #225 radio receiver. *Gene Vitori, 528 Mansel Drive, Landing, NJ 07850.*

Needed: Chronetics pulse generator service manual for model PG-13B. Will buy or copy and return. Also need the company's new address or phone number. *Richard Curtis, 1911 Santa Monica Blvd., Santa Monica, CA 90404; 213-829-2237.*

For sale: Heath IG-14 marker generator, $95. Heath TV alignment generator TS4A, $70. Heath 10-1128 vector monitor, $50. *J.M. Thurston, Thurston TV & Radio, 5738 US 33 N., Fort Wayne, IN 46818.*

Wanted: Zenith factory service manual for a chassis 14N27 TV receiver. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

For sale: Heathkit IT-3120 transistor tester and IM-5228 VTVM, assembled with manuals. $40 each including shipping. *Cavin Logue Jr., 17J Weshington Lane, Westminster, MD 21157.*

For sale: Sencore VA 48 video analyzer, $595. Complete with manuas and test leads. Good condition. Price includes shipping. *Ferrell's Electronics, P.O. Bx 160, Orrstown, PA 17244; 717-532-6238.*

For sale: Sencore SG165 stereo AM/FM analyzer. Used only once. $00 or trade for Z meter. *Robert Duncan Enterprises, 1513 Sixth St., Eureka, CA 9501; 707-442-2794 (evenings).*

Needed: Metal-cased 6L6 vacuum tube and schematic for a Geeral Radio signal generator model 1001-A, serial #2581. *David Mulks, 366 SheffieldRoad, Ithaca, NY 14850.*

For sale: B&K model 415 sweep/marker generator. Excellent condion. Manual and all cables. $125 plus shipping. *W. R. Terrill, 2121 Hill Drive, Losngeles, CA 90041; 213-257-3836.*

For sale: VTVM Heathkit IM-13, $80. Color generator, $50. TV ignment generator, $80. All in good condition and with manuals. *Jose Navorro, 6101 W Fifth St., Miami, FL 33126; 305-266-5153.*

For sale: Heath Educational Systems courses – EE-3102A, 31A, 3105A, EH-701, EH-702. All parts. Trainer ET-3100. Heath digital meter IM-25 with case. All like new, $275. *G. Guthrie, 1224 W. Ernest, Kissimmee, FL 327415-846-0452.*

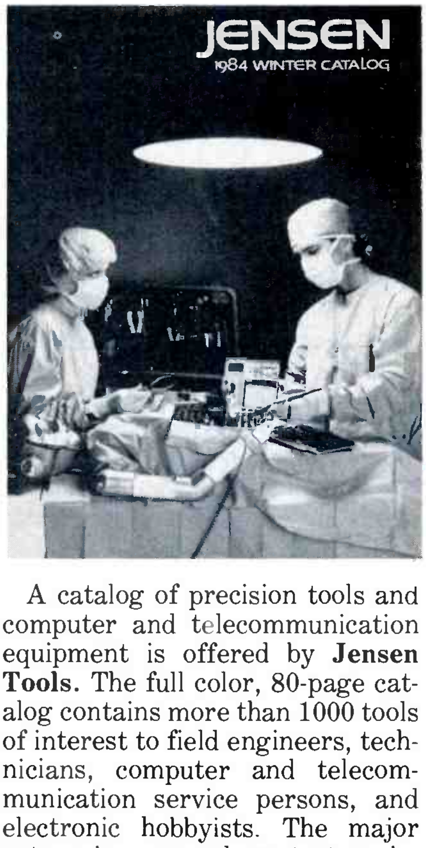
Needed: Schematic and parts list for Hurricane 350 linear aplifier, circuit board #8-058. *James A. Hannon, KWR423, P.O. Box 145, Bellville, T7418; 409-865-9882 collect.*

For sale: RCA Mark II color test jig, $75; Western Electric adard signal generator model 65B, $35; Conar model 223 tube tester, $75; and Faild digital multimeter model 7050, $25. *George C. Pullen, 6722 Botetourt Drive, FVashington, MD 20744; 301-449-7348.*

Literature

More than 80 precision test instruments, logic probes, logic monitors and solderless prototyping systems are described in a catalog from **Global Specialties.** Several new products, including high-quality computer peripherals, are included. The 1301 triple power supply has separate 5Vdc (fixed) and variable 5 to 18Vdc outputs. The model 6002 1GHz frequency counter measures from 5Hz to 1GHz, and also has period measurement. The catalog offers an overview of each product category, followed by detailed descriptions and specifications.

Circle (50) on Reply Card



A catalog of precision tools and computer and telecommunication equipment is offered by **Jensen Tools.** The full color, 80-page catalog contains more than 1000 tools of interest to field engineers, technicians, computer and telecommunication service persons, and electronic hobbyists. The major categories covered are test equipment, micro-tools, soldering equipment, tweezers, screwdrivers, cutters, drafting supplies, power tools, computer accessories and circuit board equipment.

Circle (51) on Reply Card

A 24-page, full color catalog from **Vaco** describes the new Ultra Precise pliers, professional pliers, and folding hex key sets. Other products include ball end hex tools, interchangeable blade drivers, specialty screwdrivers, a logic probe, a coax stripper, heat sinks, crimpers, and electrical connectors.

Circle (52) on Reply Card

The Eraser Company is offering an 8-page brochure describing the Rush ECT-1 electric cleaning tool and other industrial fiberglass cleaning and burnishing brushes. The brochure includes technical and application data for the brushes, which are suitable for many uses, including electrical contact cleaning, PCB cleaning, mold cleaning, commutator cleaning, rust removal and deburring of metal parts. Hand-held cleaning brushes, power operated tools and industrial brush kits for specific applications, including the cleaning of gold edge connector fingers, are described.

Circle (53) on Reply Card

RCA Distributor and Special Products Division has revised and updated its Cross Reference Volume II of TV modules for RCA TV chassis. This volume covers color chassis CTC93A through CTC121D. It cross references the modules in three different listings: stock number to module designation, module designation to stock number, and chassis to circuit.

Circle (54) on Reply Card

Coming in the August

ELECTRONIC
Servicing & Technology

The TVRO waveguide and LNA. This article describes how a satellite TV receiving system collects the microwave signal from the satellite, feeds it to the antenna and amplifies it. Low-noise amplifier specifications are also discussed.

Reports from the test lab. Carl Babcoke, ES&T's Consumer Servicing consultant reports on the results of his testing of Sencore's model VA62 Universal Video Analyzer.

Low-power microwave generators—Part II. This article continues the discussion of microwave devices begun in the July issue. An understanding of these devices will help to make such technology as TVRO and DBS receiving equipment more intelligible.

Products

Modular probes

The HZ-52 modular probe from *Hameg* (as shown in photo) is a x10 high-frequency probe with 250MHz bandwidth and 1.4ns rise time. Other probe types include the HZ-54, a x1/x10 switchable probe with 150MHz bandwidth; the HZ-53, a x100 probe with 150MHz bandwidth; and the HZ-55 RF detector probe. All the probes are repairable without tools with easily replaceable parts.

Circle (55) on Reply Card

Electric desoldering tool

This electric desoldering iron from *DTI Corporation* combines the ease and portability of a hand-held, manual, desolder pump with the performance of an industrial desolder station. The SA-6 is ac powered and does not require shop air. The vacuum chamber is simple to remove for cleaning or replacement, and the tip is self-cleaning on each stroke and easy to replace.

Circle (56) on Reply Card

Digital multimeter

The hand-held *Weston* model 7320 is designed for field-service applications. Two autoranged dc voltage ranges provide measurements to 200V with an accuracy of 0.1 percent of reading 1 digit. If connected to an ac source of greater than 20Vrms, whether a dc component exists or not, the 7320 will automatically switch to an ac mode and provide autoranged displays to 600V, 45Hz to 1kHz, with a basic accuracy of 1 percent of reading. An ac component below 20V triggers a display annunciator, and the user can then manually switch to low volts, ac to read the exact value.

A continuity mode produces an audible tone if connected to less than 10, while a diode check mode displays the forward voltage drop of a conducting diode, and an audible tone signals a normally conducting junction. Three autoranged resistance ranges to 20M are also provided.

Circle (57) on Reply Card

Digital tester

An updated model 3210 Brainmaster, a hand-held digital tester designed to troubleshoot Computer Command Control (C-3) systems on 1981-1984 General Motors cars, has been introduced by *All-Test.* The Brainmaster uses the latest in microprocessor technology to interact with the vehicle's computer. It will check all trouble codes and perform a battery of tests on sensors, solenoids and switches in two or three minutes.

Plug one lead into the car's cigarette lighter and the other into the computer connector under the dash. Select the appropriate function on the tester, dial the vehicle type, and the Brainmaster gives instant indication of any problems. The Brainmaster gives readouts on each of the C-3's trouble codes,

Circle (58) on Reply Card

Marketplace

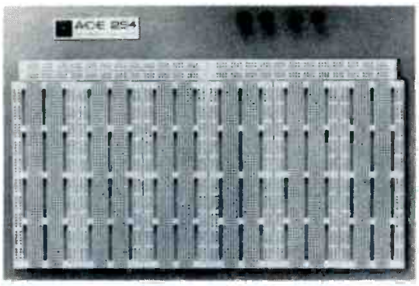
checks rpm and mph. It provides access to all sensors and solenoids and to the following switches: park/neutral, idle speed nose, air conditioning and altitude. In addition, the Brainmaster provides information on the degrees of spark retard due to engine knocking, closed loop/open loop status, cross counts and idle air control motor position (electronic fuel injection models), and vote (T-cars only).

Circle (61) on Reply Card

All circuit evaluators

AP Products has expanded its line of All Circuit Evaluators to include breadboards that can accommodate even larger testing and prototyping projects. New to the AP line are the ACE 245 and ACE 254.

The ACE 245 features a universal matrix of 4488 solderless plug-in tie-points and is composed of 640 separate 5-tie-point terminals, 40 vertical distribution buses, plus 4 horizontal buses. These buses can be used for power, ground signal lines and more.



For larger projects, the ACE 254 combines the plug-in ease of a 0.1" X 0.1" solderless matrix with the convenience of 768 separate distribution buses of 5-tie-points each, plus four horizontal buses, each with 24 connected 4-tie-point terminals. Buses may be linked in various combinations to provide voltage and ground distribution reset lines, clock lines and shift commands. The matrix of 5424 solderless plug-in tie-points accepts DIPs of all sizes and a wide variety of discrete components with leads up to 0.032" in diameter. DIP capacity is up to 54 14-pin DIPs.

Circle (59) on Reply Card

Oscilloscope

The V-1100 is a 100MHz portable oscilloscope from *Hitachi Denshi*. This full-function scope has a CRT readout that displays frequency counter and DVM functions as well as constant ground level display.

With the use of built-in microprocessor circuits, the V-1100 displays the measurement of voltage value between ground level and reference cursor or two cursors and the time difference between two points. It then determines panel settings on the CRT screen.

Additional features include quad channel with independent position controls, 8-trace with alternate sweep, 18kV – 6-inch rectangular CRT, minimum deflection factor 1mv/div, maximum sweep time 2ns/div, TV-sync, X-Y operation up to 1MHz (3° or less), variable hold-off, gate output for A and B sweep, and channel 1 signal output to 100MHz (–3db).

Circle (60) on Reply Card

ES&T

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