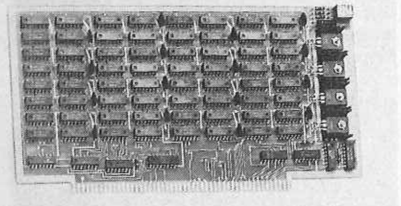
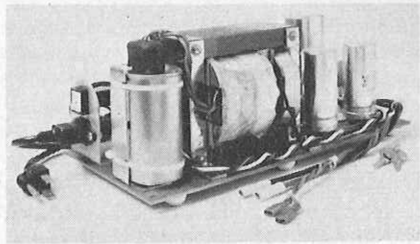
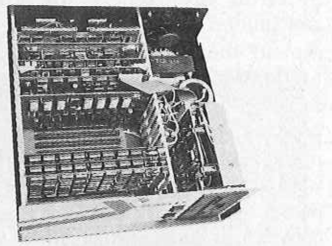
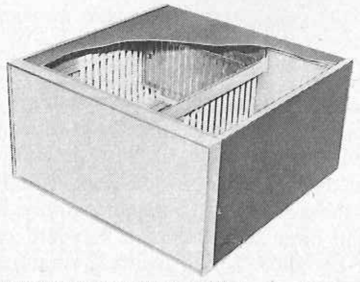
ALL ABOUT

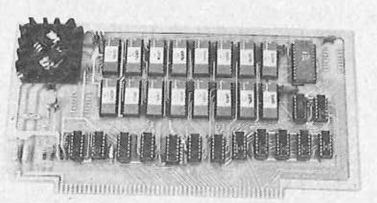
Hobby Computer Power Supplies

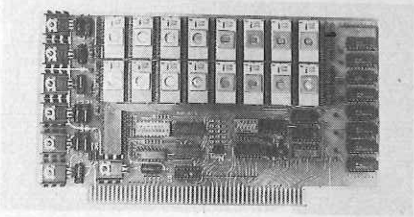

STATIC RAM MEMORY from Vector Graphic is designed for the S-100 bus structure. Four Motorola MC7805CP 3-terminal voltatge-regulator IC's are along the right-hand edge.


TYPICAL POWER SUPPLY for hobby computers has heavy power transformer and computer-grade electolytic filter capacitors. The voltage regulators are mounted on the motherboard.


VECTOR model 1+ microcomputer has power supply along right side of cabinet. Cooling fan in right rear corner exhausts hot air.


VECTOR'S VP2 ENCLOSURE permits you to design and house your own microcomputer. Card-guides are provided. Power supply can be installed in smaller compartment.


RAM MEMORY BOARD from Electronic Control Technology mates with S-100 bus. Type LM340T regulator IC's are on massive heat-sink in upper left corner.


COMBINATION RAM AND ROM memory board is designed for S-100 bus configuration. Distributed voltage regulation uses six 3-terminal voltage-regulator IC's.

The power supply is perhaps one of the most critical of all hobby computer components. TTL (Transistor-Transistor Logic) IC's, often used in microcomputer circuitry, operate from a DC supply with a nominal level of 5 volts and a maximum level that must not be allowed to go above 5.6. This is the story of high-current power supply regulation and how you can design and build your own supply.

JOSEPH J. CARR

MICROCOMPUTERS BUILT WITH THE S-100 BUS USE DISTRIBUTED regulation to supply +5 volts DC to the various circuits. Distributed regulation uses one or more three-terminal IC regulators (i.e., LM309, 7805, LM340-5) mounted on each printed circuit board. The main high-current power bus on the S-100 motherboard is unregulated +8 volts DC.

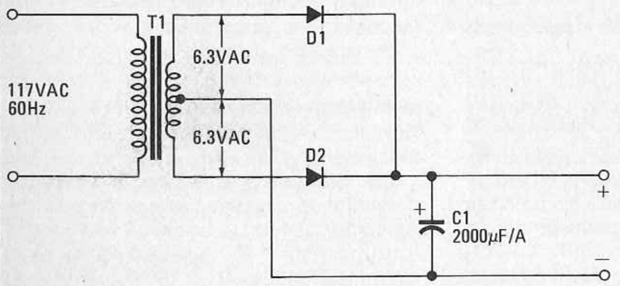


FIG. 1—SIMPLE FULL-WAVE RECTIFIER uses two diodes and a center-tapped transformer.

But certain other mainframes use +5 volts DC *regulated* on the main power distribution bus, and obtaining that type of supply at a reasonable cost is quite a chore! At current levels of around 5 amperes, you cannot use a simple three-terminal IC regulator. Finding a series-pass transistor able to handle the load current and possessing a *beta* high enough to allow use of the simple Zener-controlled base circuit type of regulator is almost impossible. In this article we will discuss several approaches to solving the problem of high-current supplies.

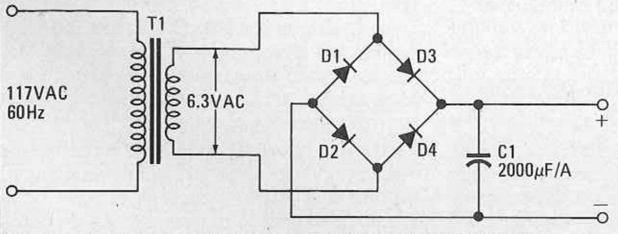


FIG. 2—BRIDGE RECTIFIER provides full-wave rectification.

Pseudo-distributed system

The microcomputer kit I purchased recently uses a motherboard with the +5 volt DC and ground foil traces connected to the individual card-edge connectors. The total current demand of a fully populated motherboard is approximately 16 amperes. In trying to develop a power supply, one solution I tried with moderate success was to cut the +5-volt foil trace on the motherboard at strategic points, and then mount external three-terminal IC regulators nearby. One regulator served each section of the board. The three types mentioned earlier are suitable for current drains of 1 ampere in the TO-3 case, and 750 mA in the plastic case. The LM323 will handle 3 amperes, and the Lambda LAS-1905 will handle 5 amperes.

The pseudo-distributed system works well, but is sloppy. In some cases, this approach is made more difficult by the fact that not all motherboards are laid out in the nice straight lines of the S-100 bus! The +5-volt DC line may wander, breaking off at points, and then rejoining later on. These difficulties often force us to look at other alternatives.

Rectifiers and filters

In the regulator circuits to follow we will show only the regulator and associated circuitry, since this is where the main problem in design is. All these circuits will be preceded by a rectifier and filter circuit such as those shown in Figs. 1 and 2.

Both of the circuits shown in Figs. 1 and 2 are full-wave rectifiers, meaning that they make use of both alternations of the AC sinewave from the power mains. This type of rectifier is not only easier to filter (the traditional justification) but also results in a higher average DC output voltage, and requires less power (i.e., V × A) from the transformer primary for any given load current.

The rectifier circuit in Fig. 1 uses two solid-state diodes and a center-tapped transformer. The center tap is taken as the common (or ground) terminal, while the positive output is taken from the junction of the two diode cathodes. The alternate circuit, shown in Fig. 2, is a bridge rectifier that can be made from four discrete diodes, or be purchased as a prepackaged bridge.

Almost all voltage regulator circuits require a DC input that is at least 2.5 volts higher than the rated output voltage. In our case, with +5-volts DC output, the DC input voltage should be not less than +7.5. In case you have wondered, this is probably the reason why Altair, the original S-100 bus designers, specified +8 volts for the main power bus. An ordinary 6.3-volt AC (RMS) filament transformer will deliver this potential when full-wave rectified and filtered. The filter will charge to 1.4 × E_{RMS}, which in this case is 1.4 × 6.3 = 8.8 volts. In most cases, a 6.3-volt high-current filament transformer is sufficient.

The standard 6.3-volt filament transformer is a good choice for use in a circuit such as Fig. 2 because the bridge rectifier uses the entire secondary. Keep in mind, however, that the *transformer can deliver only half its rated current in the bridge configuration.* In the case of Fig. 1, a 12.6-volt transformer will provide 6.3 volts AC either side of the center tap, so it is a good choice. It will deliver the same output potential as the bridge rectifier used with a 6.3-volt transformer, and will supply its rated current.

Fortunately, 6.3 and 12.6 volts AC are the filament ratings of many high-power transmitting tubes used in commercial and military transmitters. Many such transformers are still available on the surplus market, although the supply is down from its heights of only a few years ago. You should be able to save a considerable amount of money by checking the local electronic surplus outlets, ham friends (who tend to save such items), or by attending hamfests and auctions. If a push comes to a shove, or you have money to spend, then go to your local parts distributor and buy a new transformer outright. I have used several Triad types that are particularly useful because their tapped primary offers secondary AC voltages of either 6.3 or 7.5. Table 1 gives the type numbers and ratings.

The rectifier diodes or bridge-rectifier stacks should be rated to handle more current than is expected at full load, but keep in mind that they will tend to run very hot if operated at a point near their maximum ratings. It is preferable to select diodes with a 25 or 50 percent margin. For example, for a 20-ampere power supply select a 25- to 30-ampere diode. Also keep in mind that the minimum peak inverse voltage (PIV) rating must be not less than 2.82 times the applied RMS voltage. This is not too much of a problem in +5-volt circuits operated from 6.3-volt transformers, but is very definitely a factor at higher voltages. You cannot, for example, use a 25-volt PIV rectifier in a 12-volt DC supply!

TABLE 1—TYPICAL FILAMENT TRANSFORMERS

Triad No.	Secondary voltage	Amperes
F-22U	6.3VAC	20
F-24U	6.3/7.5 VAC	8
F-28U	6.3/7.5VAC	25
F-56X*	25.2 VAC	2.8

*Ideally suited to making the ±12 volt regulated supplies needed for most microcomputers. Use a fullwave bridge *and* the transformer center tap to form two halfwave bridges. This supply will deliver up to 1 ampere at each voltage.

Capacitor C1 in Figs. 1 and 2 should have a capacitance of *not less* than 2000 μF-per-ampere of load current. In a 20-ampere supply, then, the filter capacitor should be at least 40,000 μF. It should have a DC working voltage rating of at least 15 volts (WVDC). I used an 80,000 μF/15 WVDC capacitor in testing these circuits with a 15-ampere load. The 2000 μF-per-ampere spec is a *minimum*, not an *optimum*, rating.

The 5-volt, 5-amp supply

The Lambda Electronics (515 Broad Hollow Rd., Melville, L.I., N.Y., 11746) model LAS-1905 is one of the most powerful

5-volt three-terminal IC regulators on the market; it has an output-current specification of 5 amperes!

Figure 3 shows a typical circuit using the LAS-1905. Note that this circuit is not too much different from other three-terminal IC regulator circuits. This regulator, however, has better protection than some less powerful and less costly versions. Some of the features more than justify its $14 price tag. A block diagram of the internal circuitry is shown in Fig. 4. Note that it contains safe-area protection, thermal-overload protection and the all-important current-limiting protection.

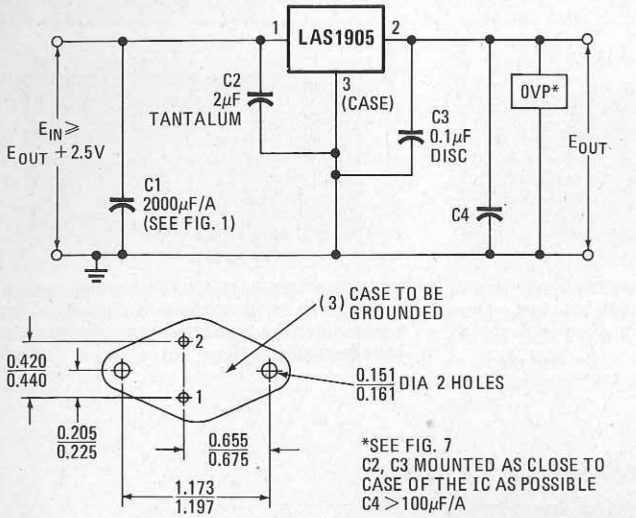


FIG. 3—THREE-TERMINAL IC REGULATOR provides 5 volts at 3 amperes.

The use of current-limiting is almost mandatory once the current level goes much over an ampere or two because of the damage short circuits can cause to printed-circuit traces and other components, including the power supply itself! As the current level increases, so does the possibility of vaporizing the main power bus in your mainframe! In my own Z-80 system, current-limiting saved the motherboard once when some of the protective foil that comes wrapped around 2102 memory IC's accidentally stuck to a printed-circuit card right where the +5-volt DC and ground terminals enter the board. Without the 10-ampere current-limiting circuitry then used in my supply (the circuit in Fig. 5), the tracks may well have vaporized!

The power supply regulator in Fig. 3 is especially useful for powering single-board computers that normally tax 3-ampere regulators, and wipe out 1-ampere types! Note that most regulators tend to offer deteriorated transient response near their full rated output current, so the extra margin of the LAS-1905 would prevent certain types of power-supply-induced "glitch." Use the LAS-1905 for applications where an LM-323 might have to work close to its 3-ampere rated output current.

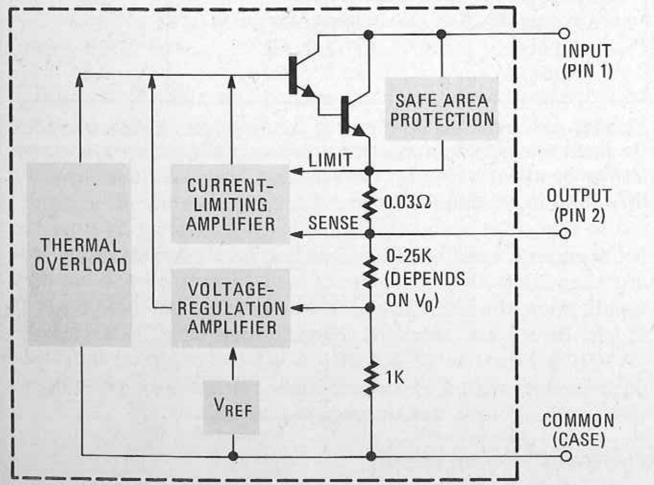


FIG. 4—INTERNAL CIRCUITRY of Lambda Electronics LAS-1905 three-terminal regulator.

A 5-volt DC, 10-amp supply

Figure 5 shows a regulator circuit taken from the Motorola applications literature on their MC1469R voltage regulator IC. This circuit can deliver up to 10 amperes with the transistor shown and the 60-milliohm series resistor. The same circuit can deliver up to 15 volts DC for use with CB and ham transceivers if resistors R4 and R5 are changed appropriately. The output voltage is given (approximately) by the formula

$$E_{out} \simeq 3.5 \times 1 + \frac{R4}{R5} - 0.6$$

Transistor Q2 and resistor R1 serve as the current-limiting circuit, and will shut down series-pass regulator Q1 if the voltage drop across R1 exceeds 0.6; the forward bias potential of Q2. The maximum output current, then, is set by resistor R1 and is equal to 0.6/R1. In the case of our 10-ampere supply, R1 is 60 milliohms, i.e., 0.060 ohm. This is not a standard off-the-shelf value so it must be made. I used five 0.33-ohm auto radio fuse resistors, while a friend made one from magnet wire using the ohms/foot data given in the ITT *Radio Engineers Data Book* (Howard W. Sams & Co.).

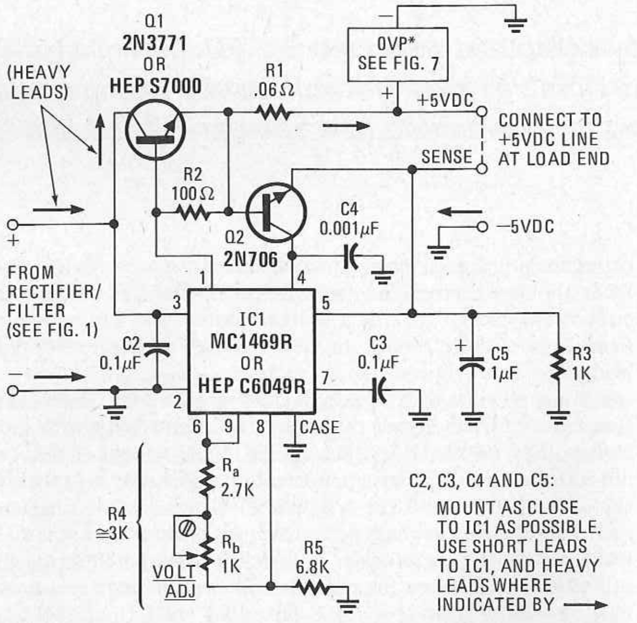


FIG. 5—10-AMPERE REGULATOR based on Motorola IC regulator and series-pass transistor.

The power supply in Fig. 5 uses a *sense* line. The MC1469R regulator is a feedback type that uses an error amplifier to compare the actual output voltage with an internal reference voltage. The sense terminal is the input to the internal error amplifier. In supplies that deliver more than 5 or 10 amperes, it is considered good engineering practice to run the sense line to the load separately from the main power bus. This arrangement allows the regulator to sense the voltage actually delivered to the load, rather than the regulator output voltage. If the main power bus is more than a few inches long, or if it is made of a marginally sized conductor, then the IR-drop due to current flow can be considerable. In one large-scale TTL project I built, this drop was almost 1 volt in an 18-inch line, and that can cause all kinds of trouble in ticklish TTL circuits! There are enough real problems in digital electronics without making more by poor power supply technique!

5-volt, 20- or 30-amp supply

The design and construction of a thermally stable, regulated, power supply able to deliver over 10 amperes or so is not an easy chore. While it is easy to theorize on paper, you find that it is a long way from the design desk to the final product! Techniques that should have worked sometimes succumb to some unsuspected glitch or hitch that inevitably fouls up the works. In that case, it might be wise to use a 20- or 30-ampere hybrid voltage regulator such as the Lambda LAS-5205 (20 A) or LAS-7205 (30 A). Figure 6 shows a circuit based on these devices. Both of these modules contain all required circuitry to make a regulator circuit with complete current-limiting and thermal-overload protection.

These regulators have two heat-dissipating surfaces. The lower and larger of the two is thermally connected to the high-current series-pass transistors, while the upper is thermally connected to the regulator reference and control circuitry, affording a degree of thermal isolation for these circuits. The regulators also have two separate E_{in} terminals, labeled E_{in1} and E_{in2} in Fig. 6. Terminal E_{in1} is to the main series-pass transistor, and must be at a potential of 2.5 volts higher than E_o, or in this 5-volt example, 7.5 volts DC. The other terminal, E_{in2}, supplies the control circuitry and must be at a potential that is 7.5 volts greater than the output potential, or in this case, 12.5 volts. If the main, high-current, supply delivers a potential of 12.5 volts or more from the rectifier-filter, then E_{in1} and E_{in2} may be strapped together. But if an 8-volt DC high-current supply is used, then E_{in2} must be tied to some other source. In most microcomputers there is a +12-volt regulated supply, and this will usually be fed from a +15-volt unregulated source. Use the +5-volt terminal to supply E_{in2} in that case.

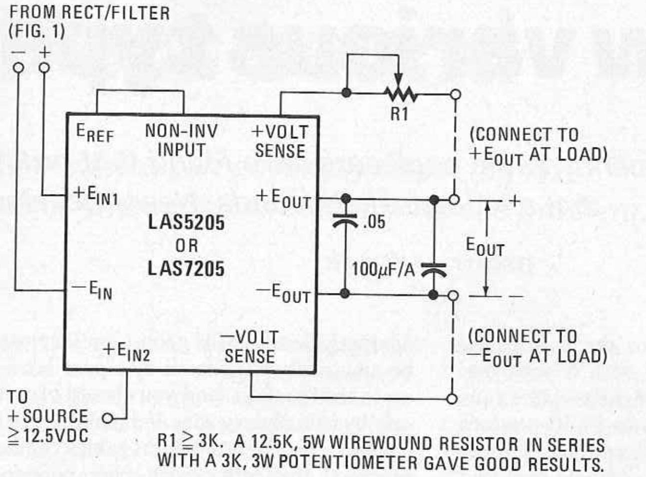


FIG. 6—HYBRID REGULATOR circuit and external components can be used to provide output currents in the 20- to 30-amp range.

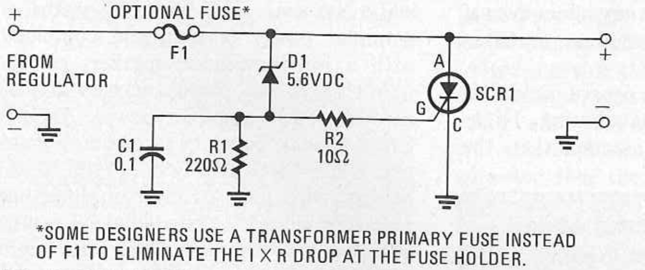


FIG. 7—SCR CROWBAR using discrete components provides short-circuit protection.

The high cost of these hybrid modules may seem a little steep for amateur and hobbyist use, until one begins to price out commercial +5-volt, 20-ampere supplies. There is at least one on the market that will deliver the current and costs only $115, but most run closer to $200. The $80 price of the LAS-5205 then seems less frightening, especially if you are able to scrounge or buy the transformer and filter capacitor from a surplus source. Note that 6.3- and 12.6-volt center-tapped transformers have a high "scroungability" quotient!

Overvoltage protection

All series-pass transistors work hard and tend to get very hot inside of the case. This heat tends to cause marginal transistors to give up and short out prematurely, which would place the full rectifier-filter voltage on the main power bus of your expensive computer. TTL IC's may well blow out with as little as 7 or 8 volts, so the short-prone series-pass transistor is a scenario for disaster! Your cabinetful of expensive microcomputer may well become a *silicone*-to-carbon converter in a quick hurry!!!

The way to protect your equipment from this type of disaster is to use an overvoltage-protection circuit such as the SCR crowbars of Figs. 7 and 8. The circuit in Fig. 7 uses discrete components, while the circuit in Fig. 8 is an IC version produced by Lambda.

The circuit in Fig. 7 uses a high-current SCR to blow the main bus fuse if an overvoltage condition is sensed. This brute force approach is probably the origin of the inelegant nickname "crowbar." Diode D1 is a 5.6-volt Zener, so it will not pass current as long as the output voltage is normal (i.e., +5 volts). But if the series-pass transistor goes bananas and places the +8 volts on the output, then D1 will conduct and pass current to the gate of SCR1. This current will turn on SCR1, creating a short circuit across the +5-volt line, thereby blowing the fuse. Not very elegant as circuits go, but it will save hundreds of dollars worth of circuitry in the event of a catastrophe. Select an SCR with a current rating considerably higher than the line current; a 30- to 50-ampere rating will do nicely.

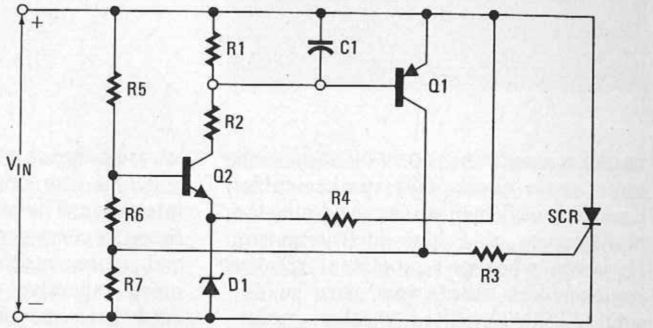


FIG. 8—CROWBAR PROTECTION circuit from Lambda Electronics is available in self-contained modules.

I have used the 2-, 6- and 35-ampere Lambda two-terminal overvoltage protectors in various power supplies. In my main computer mainframe, an L-35-OV-5 is used as a reasonably priced alternative to the discrete circuit. The internal circuitry for these devices electronic crowbar is shown in Fig. 8 while the ratings of various 5-volt models (i.e. 6.6V trip point) are given in Table 2.

Transient protection

Lightning and other disturbances can create voltage transients close to 1000 volts on the primary side of your computer supply. One amateur computernik friend of mine lost over 20 TTL devices in a single thunderstorm! The General Electric MOV (metal-oxide varistors) offer some degree of protection against this type of damage. Check the GE literature for a suitable model for the current level expected.

TABLE 2—CROWBAR PROTECTION MODULES

Lambda Model No.	Current Rating*
L2-OV-5	2 amperes
L6-0V-5	6 amperes
L12-OV-5	12 amperes
L20-OV-5	20 amperes
L35-OV-5	35 amperes

*All models have a trip voltage of 6.6 volts

continued on page 101

BEST IN NEW ELECTRONICS BOOKS!

☐	Digital Interfacing With An Analog World 406 p., 277 il.	$8.95
☐	Illus. Dictionary of Microcomputer Terminology 322 p., 150 il.	$7.95
☐	How To Design/Build Your Own Custom TV Games 546 p.	$9.95
☐	The Complete Handbook of Robotics 364 p., 137 il.	$7.95
☐	24 Tested, Ready-To-Run Game Programs In BASIC 266 p.	$5.95
☐	Beginner's Guide to Computers/Microprocessors 308 p.	$6.95
☐	Direct Current Motors — Characteristics & Applications	$14.95
☐	303 Dynamic Electronic Circuits 308 p., 303 il.	$6.95
☐	How To Design, Build, Test Complete Speaker Systems 336 p.	$6.95
☐	Antenna Construction Handbook for Ham, CB & SWL 238 p.	$5.95
☐	First Class Commercial FCC License Study Guide 378 p.	$7.95
☐	Radar Detector Handy Manual 80 p., 48 il.	$2.25
☐	Jap Radio, Record, Tape Player Schem./Svcing. Manual #2	$7.95
☐	CBer's Handy Manual of Base Stations 96 p., 55 il.	$2.50
☐	The Handbook of Telephones & Accessories. 432 p., 215 il.	$9.95
☐	Install Electronic in Cars, Boats, Planes, Trucks & RV's 384 p.	$7.95
☐	The BASIC Cookbook. 140 p., 49 il.	$4.95
☐	How to Repair Video Games. 270 p., 182 il.	$7.95
☐	Beginner's Gde.-Designing/Building Trans. Radios. 140 p.	$4.95
☐	Towers' International FET Selector, 140 p.	$4.95
☐	How to Design/Build Electronic Instrumentation. 420 p.	$9.95
☐	How to Repair Movie & Slide Projectors. 304 p., 270 il.	$7.95
☐	Understanding Sound, Video & Film Recording. 140 p., 74 il.	$5.95
☐	Build-It Book of Solar Heating Projects. 196 p., 111 il.	$4.95
☐	Hdbk. of Solar Flare Monitoring/Propag. Forecasting. 196 p.	$6.95
☐	57 Practical Programs & Games in BASIC. 210 p., 611 il.	$7.95
☐	Hearing Aid Handbook. 432 p., 224 il.	$8.95
☐	CMOS Databook. 280 p., 270 il.	$6.95
☐	Master OP-AMP Applications Handbook. 476 p., 320 il.	$9.95
☐	Miniprocessors: From Calculators to Computers. 196 p., 67 il.	$5.95
☐	Complete Hdbk. of Public Address Sound Systems. 272 p.	$7.95
☐	Modern Transistor Radios. 64 p., 112 il.	$2.50
☐	Microwave Oven Service & Repair. 420 p., 210 il.	$9.95
☐	Solid-State Motor Controls. 322 p., 162 il.	$8.95
☐	Master Handbook of Ham Radio Circuits. 392 p., 301 il.	$8.95
☐	Towers' International Transistor Selector. 200 p., 179 il.	$6.95
☐	Ham Radio Incentive Licensing Guide. 154 p., 70 il.	$4.95
☐	Programming Microprocessors. 280 p., 102 il.	$6.95
☐	The "Compulator" Book — Build Super Calculators 322 p.	$7.95
☐	Master Transistor/IC Substitution Handbook. 518 p., 165 il.	$7.95
☐	Home-Brew HF/VHF Antenna Handbook. 210 p., 143 il.	$5.95
☐	CBer's Handy Manual of SSB. 80 p., 42 il.	$2.25
☐	Beginner's Gde.-Making Electronic Gadgets. 140 p., 113 il.	$4.95
☐	Modern Digital Communications. 308 p., 122 il.	$6.95
☐	Microprocessor Progr.-Computer Hobbyists. 378 p., 219 il.	$8.95
☐	Illus. Dict.-Broadcast/CATV/Telecommunications. 420 p.	$8.95
☐	Linear IC Applications Handbook. 280 p., 183 il.	$6.95
☐	Build-It Book of Optoelectronic Projects. 238 p., 175 il.	$5.95
☐	How to Use AF & RF Signal Generators. 238 p., 162 il.	$5.95
☐	Model Railroad Electronics. 308 p., 218 il.	$5.95
☐	The ABC Book of Hi-Fi/Audio Projects. 182 p., 131 il.	$4.95
☐	Complete Hdbk. of Electrical/House Wiring. 476 p., 197 il.	$6.95
☐	88 Practical Op Amp Circuits You Can Build. 140 p., 120 il.	$4.95
☐	How to Build Metal/Treasure Locators. 140 p., 60 il.	$3.95

SEND NO MONEY! We'll invoice you on **10-DAY FREE TRIAL**. Clip entire ad to order. 100% guaranteed or your money refunded

TAB BOOKS DEPT RE-128
BLUE RIDGE SUMMIT, PA 17214

CIRCLE 28 ON FREE INFORMATION CARD

You Can Count On DAVIS!

NEW CTR-2A
500 MHz & 1 GHz COUNTERS
NOW WITH
PERIOD MEASUREMENT (Optional)
AND BUILT-IN PREAMP

- *8 Digit .3" LED Display*
- *High Stability TCXO Time Base*
- *Built-in VHF-UHF Prescaler & Preamp*
- *Period 1us to 1 sec. (optional)*
- *TCXO Std. ± 2 ppm*
- *Input Diode Protected*
- *12V-DC Operation (optional)*
- *Oven Crystal ± .5 ppm (optional)*
- *Selectible Gate Times .1 sec. & 1 sec.*

500 MHz kit CTR-2A-500K	$249.95
500 MHz assembled CTR-2A-500A	349.95
1 GHz kit CTR-2A-1000K	399.95
1 GHz assembled CTR-2A-1000A	549.95

OPTIONS:

(02) Oven Crystal	$49.95
(03) .43" LED	10.00
(04) 12 V-DC	10.00
(05) 10 sec. Time Base	10.00
(06) Period Option	15.00

DAVIS

DAVIS ELECTRONICS
636 Sheridan Drive
Tonawanda, NY 14150
716/874-5848

master charge VISA

CIRCLE 47 ON FREE INFORMATION CARD

books

MICROCOMPUTER HANDBOOK, by Charles J. Sippl. Petrocelli/Charter, Div. Mason/Charter Publishers, Inc., 641 Lexington Ave., New York, NY 10022. 454 pp. 6½ × 9½ in. Hardcover $19.95.

This book is designed to serve the needs of designers, students, hobbyists and all those who require a thorough understanding of low-cost microminiaturized computer systems. Systems engineers and developers who must integrate these computers into existing systems will also find this book a useful guide.

Early chapters deal with and contrast standard computers and minicomputers. Other chapters describe the various types of microcomputers and their capabilities, software, programs and many applications. All terminology is carefully defined, and photos and diagrams clarify the text.

THE DESIGN OF OPERATIONAL AMPLIFIER CIRCUITS, WITH EXPERIMENTS, by Howard M. Berlin. E&L Instruments, Inc., 61 First St., Derby, CT 06418. 266 pp. 6 × 9 in. Softcover $8.50.

The beginning experimenter and hobbyist will find this latest in the *Bugbook* series useful in a home study program dealing with the design and operation of different types of op-amp circuits. Each chapter contains its own set of experiments on a wide spectrum of circuits, from linear amplifiers to single-supply units. Chapter 1 introduces the reader to the basics; other chapters deal with the fundamental circuits using bipolar and Norton-type op-amps; and Chapter 10 discusses the instrumentation amplifier used in augmenting low-level signals.

WORKSHOP IN SOLID STATE, Second Edition, by Harold E. Ennes. Howard W. Sams & Co., Inc., 4300 W. 62nd St., Indianapolis, IN 46268. 384 pp. 5½ × 8½ in. Softcover $7.95.

The student and technician with previous training in electronics will find this book helpful in making the transition from vacuum-tube circuitry to solid-state devices. The material was originally developed to aid in training broadcast technicians, but the basic principles apply to other branches of electronics as well.

The text covers the fundamentals of solid-state devices, circuits for both linear and pulse applications, logic-circuit principles and testing and servicing information. Test questions follow most chapters, with answers in an appendix in the back of the book.

HOME-BREW HF/VHF ANTENNA HANDBOOK, by William Hood. TAB Books, Blue Ridge Summit, PA 17214. 210 pp. 5 × 8¼ in. Softcover, $5.95; hardcover, $8.95.

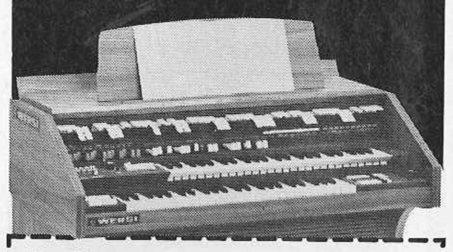
This how-to guide on building antennas contains complete down-to-earth instructions on designing, constructing, installing, selecting, buying and customizing any HF/VHF antenna, from a basic dipole to stacked-beam arrays. The first two chapters deal with essential antenna principles, formulas, systems and configurations. Also included are in-depth examinations of wave propagation, radiation characteristics, transmission lines, baluns, etc., plus instructions and schematics for constructing dummy antennas, SWR meters, impedance bridges, L- and Pi-networks, and many more. Contains four appendixes and an index. **R-E**

FREE SWTPc CATALOG

Audio—Computers
Instruments
Kits & Assembled

Southwest Technical Products Corporation
219 W. RHAPSODY
SAN ANTONIO, TEXAS 78216

CIRCLE 57 ON FREE INFORMATION CARD



Try this exciting new hobby! Build your own electronic concert organ. It's easy. No technical knowledge required. Just follow the clearly pictured instructions of the famous Wersi do-it-yourself system. Choose from seven different models. Send $2.00 (refundable) with coupon for colorful 104 page catalog.

WERSI

Wersi Electronics, Inc.
Dept. 42,
1720 Hempstead Road
Lancaster, PA 17601

Enclosed is $2.00 for my copy of your 104 page catalog.

Name ______________________
Address ______________________
City ____________ State __________ Zip _____

CIRCLE 29 ON FREE INFORMATION CARD

next month

JANUARY 1979

- **Build An Audio Test Station**
- **How To Troubleshoot Communication Receivers**
- **Build An Arcade Quality Motorcycle Game**
- **All About Optical Fiberquides**
- **Simplifying The Wire-Wrap Jungle**

PLUS

Lab Tested Hi-Fi Test Reports

Build A Compact 600 MHz Freq Counter

CET Test

Computer Corner

HOBBY COMPUTER POWER SUPPLIES

Continued from page 59

Keep it cool

While giant strides have been made in the miniaturization of electronic components, nobody has yet miniaturized the *joule* (i.e., watt-second). Heat causes many electrical component failures, and it is likely that series-pass transistors and regulators will fail if allowed to get too hot. Additionally, most such devices have a temperature coefficient that defines an output voltage change in percent-per-degree centigrade (%/°C).

At current levels up to about 5 amperes, ordinary heat-sinking and convection cooling will usually suffice, but at higher current levels it becomes increasingly necessary to use a blower or fan in addition to the heat sink.

In one configuration of my Z-80 system, I used a heat-sinked HEP S7000 in the circuit of Fig. 3 to provide 5 volts at 10 amperes. The heat sink was one of the large finned International Rectifier models sold in hobbyist outlets. This transistor got so hot after 20 minutes of operation at near full load that a first degree burn would reward anyone foolish enough to touch it! But a 50-cfm "whisper" fan reduced the temperature to the "barely hot" level in only a few minutes!

In short, it is good practice to always use forced-air cooling on power regulators and series-pass transistors operated at more than a few amperes of constant load current. Keeping the case temperature low will not only improve longevity, but will also prevent output voltage drift due to thermal changes. The rules for keeping a regulator and rectifier cool are:

1. Mount the IC regulator, series-pass element and rectifiers on heat sinks, not just on the chassis.
2. Use silicone/heat-transfer grease between all devices and their respective heat sinks.
3. Blow 40 to 105 cubic-feet-per-minute (cfm) of air across the heat-sink fins. Such fans or blowers can usually be obtained at low-cost surplus or somewhat higher cost at retail. The investment is well worth it—remember that bit about the silicon-to-carbon converter! **R-E**

INTERNATIONAL FM-2400CH

FREQUENCY METER FOR TESTING MOBILE TRANSMITTERS AND RECEIVERS

• Portable • Solid State • Rechargeable Batteries

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

The FM-2400CH with its extended range covers 25 to 1000 MHz.

The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz.

Frequency stability: ±.0005% from +50° to +104°F.

Frequency stability with built-in thermometer and temperature corrected charts: ±.00025% from +25° to +125° (.000125% special 450 MHz crystals available).

- **Tests Predetermined Frequencies 25 to 1000 MHz**
- **Extended Range Covers 950 MHz Band**
- **Pin Diode Attenuator for Full Range Coverage as Signal Generator**
- **Measures FM Deviation**

FM-2400CH (meter only) Cat. No. 035320	**$595.00**
RF crystals (with temperature correction)	**24.90** ea.
RF crystals (less temperature correction)	**18.90** ea.
IF crystals	**catalog price**

Write for catalog

ICM

INTERNATIONAL CRYSTAL MFG. CO., INC.
10 North Lee / Oklahoma City, Okla. 73102

CIRCLE 73 ON FREE INFORMATION CARD