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VERSATILE IN APPLICATION

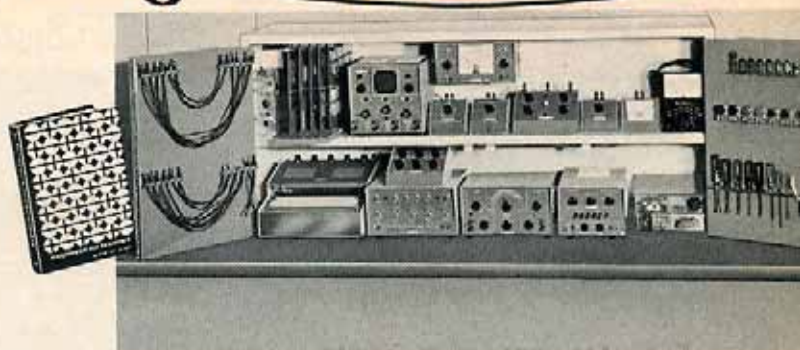
RESEARCH IN INDUSTRY AND GOVERNMENT

RESEARCH IN ALL SCIENCES USING ELECTRONIC INSTRUMENTATION



MEDICAL ELECTRONIC RESEARCH INSTRUMENTATION

COLLEGE AND UNIVERSITY CLASSROOM AND LABORATORIES



All Instruments are also Available Separately

Universal Power Supply
Model EUW-15...\$75.00—Page 87



Operational Amplifier System
Model EUW-19A...\$135.00—Page 88

Servo Chart-Recorder
Model EUW-20A...\$195.00—Page 88



Voltage Reference Source
Model EUW-16...\$65.00—Page 87

Transistorized Power Supply
Model EUW-17...\$20.00—Page 87



Lab Meter with shunts
Model EUW-18...\$22.00—Page 84

The Malmstadt-Enke INSTRUMENTATION LABORATORY ... a coordinated system of instruments, accessories, and text for research or educational purposes

- Heath quality and value
- New styling ... New features ... New value for '64
- A complete electronics lab for scientists, educators, & engineers
- Ideal for teaching electronics to both graduate and undergraduate scientists
- Perfect for everyday use in research labs
- System compares with equipment costing as much as \$20,000!
- All equipment factory wired and tested
- "Solderless" spring-clip connectors in experimental parts groups
- Authoritative Malmstadt-Enke textbook "Electronics For Scientists"

The Heath EU-100A "Malmstadt-Enke Instrumentation Laboratory" is a coordinated system of special experimental kits, wired and tested electronic instruments, and informative textbook that will prove to be of priceless value to the scientist, educator, and researcher! The system was engineered by Heath in close association with Dr. Malmstadt of the University of Illinois and Dr. Enke of Princeton University, who originated the system and authored the widely acclaimed text "Electronics for Scientists".

The EU-100A station contains all of the parts and instruments necessary to provide chemists, physicists, engineers, medical scientists, biologists, and all students and research workers with a firm working knowledge of circuits and modern instrumentation that will prove invaluable in their work. These stations are rapidly being introduced into college, university and industrial courses at all levels—technician, undergraduate, graduate and postdoctoral. We will be happy to send you a folder of laboratory layouts showing up to 30 stations in a lab. Private stations are also being used by scientists and engineers in their own homes and individual research labs on a self-instruction and application basis.

Specific instruments within the EU-100A station serve multipurpose applications—for instruction, research, development and control. For example the EUW-20A servo recorder (p. 86) is useful in learning about servo systems and null-point recorders; it is ideal in the research or development lab for recording pressure, speed, temperature, strain, light radiation, etc. when used with suitable transducers; it could be modified to a sensitive and accurate pH meter (with a simple plug-in adapter) for use in research or control labs. The EUW-19A operational amplifier system (p. 86) can be used with various plug-in adapters to provide dozens of laboratory devices. Watch for future adapters to increase the laboratory applications of the EU-100A units!

The new desk-top cabinet (illustrated) was designed specifically for the EU-100A station. It provides efficient use and storage of the hundreds of parts and instruments. In this cabinet everything is in the line-of-vision and at finger-tip control. It contains 10 labeled power outlets, all the hardware for holding tools, leads, and other parts. Construction is of wood with rugged steel framing with fold-back doors that lock. The cabinet is made to sit on a regular 30" x 60" desk or equivalent bench space. By purchasing the EUP-22 cabinet at the same time as the EU-100A station you can be completely set up and operating at an efficient station within a couple hours after delivery. Great care has been exercised so that complete laboratory of several EU-100A stations can be put in operation within a day.

No other lab system available today provides as great a degree of capability and versatility as the EU-100A at so low an acquisition cost ... performance rivals that of a station that might cost as much as \$20,000!

All components of this station are available separately or as a complete system. An export version is also available. See pages 86 & 87 for additional information on the EU series and write for a free descriptive brochure. For more detailed information order the EUP-11 textbook and we will include a copy of the complete instruction manual for the entire EU-100A system at no extra cost. The instruction manual, EUA-11, is also available separately at a nominal cost of \$2.50.

BUY THE COMPLETE MALMSTADT-ENKE STATION AND SAVE!

EUP-11 Text, "Electronics for Scientists".....	\$ 11.50
EU-13A Universal Experimental Chassis & Parts.....	\$ 177.00
EU-14A Special Experimental Chassis & Parts.....	\$ 64.00
EUW-15 Assembled Universal Power Supply.....	\$ 75.00
EUW-16 Assembled Voltage Reference Source.....	\$ 65.00
EUW-17-Assembled Transistorized Power Supply.....	\$ 20.00
EUW-18 Assembled Lab Meter with Shunts.....	\$ 22.00
EUW-19A Assembled Operational Amplifier System.....	\$ 135.00
EUW-20A Assembled Servo Chart-Recorder.....	\$ 195.00
EUW-24 Wired VTVM.....	\$ 62.00
EUW-25 Wired DC Oscilloscope.....	\$ 163.00
EUW-26 Wired VOM.....	\$ 55.00
EUW-27 Wired Sine & Square Wave Generator.....	\$ 94.00
EUW-28 Wired Resistance Substitution Box.....	\$ 16.00
EUW-29 Wired Capacitance Substitution Box.....	\$ 14.00
EUW-30 Wired Decade Resistance.....	\$ 34.00
GH-10 Deluxe Tool Kit.....	\$ 19.95
Total.....	\$1222.45
EU-100A Special Group Price (includes all items above).....	\$1100.00
(Educational Institutions qualify for additional group discount)	
Export models available for 115/230 VAC, 50-60 cps; write for details.	
EUA-11 Manual.....	\$ 2.50
EUP-22 Desk Top Cabinet.....	\$ 100.00

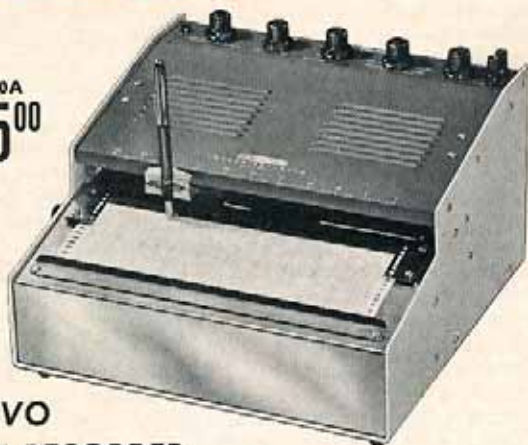
FREE FOLDER

Full details about the Malmstadt-Enke Lab system and components ... descriptions, specifications, and prices. Write for your FREE copy now.



TEST INSTRUMENTS

EUW-20A
\$195⁰⁰



Heath SERVO CHART RECORDER

- Completely assembled, tested, and ready to operate
- Characteristics compare with chart recorders costing 5 times this price
- True potentiometric null-point balance on all ranges
- Five fixed ranges (10, 25, 50, 100, 250 millivolts full scale)
- Range continuously variable from 250 mv to less than 10 mv
- Multi-purpose applications as a servo system
- Input circuit easily modified with 5-pin connectors
- Uses inexpensive, practical cartridge-type pen
- Rapid chart advance for easy chart positioning
- Convenient pen lift and paper tear-off guide
- Full 10" of pen travel
- Time scale quickly altered by interchangeable chart motors
- Designed as part of the Malmstadt-Enke Instrumentation Lab

The Heath EUW-20A chart recorder offers features and performance comparable to units costing five times this price. Also, it has unique features that are found in no other unit. In normal operation it is a precision laboratory-type self-balancing potentiometric recorder. It can be used to record pressure, speed, temperature, strain, pH, light radiation, and many other phenomena when connected to suitable transducers. In addition, it is easily modified for multi-purpose applications as a servo system. It can be quickly reconnected for use as a servo constant-current source, a servo Wheatstone bridge, and other servo-devices. Three 5-pin connectors enable rapid modifications for use in new research and development problems requiring a high-quality servo system.

Soon to become available is a blank adapter chassis that plugs into the back of the recorder. Many adapters can be constructed for performing specific laboratory functions. One useful adapter will convert the recorder to a versatile, extremely sensitive direct-reading and/or recording pH meter. Other adapters will provide for other important scientific measurements. The EUW-20A (just one of the units from the EU-100A instrumentation station, p. 41) is truly a multi-purpose instrument. In addition to its use as a precision measuring device, it is an ideal educational unit for learning about servo-mechanisms.

Some other desirable features of the recorder include the use of an inexpensive marking pen, a unique standby circuit, and impedance reduction damping. The use of standard, easily obtainable cartridge-type pens makes it possible to obtain multicolor charts merely by changing the pens. The special standby circuit prolongs the limited-life components in the recorder, such as the Mercury reference cell and the chopper, by switching them out of the circuit when not recording. The impedance reduction damping feature of the recorder makes it possible to introduce damping into the servo system without appreciably increasing the dead zone.

EUW-20A... 20 lbs... no money down, \$19 mo... **\$195.00**
Export model available for 115/230 VAC, 50-60 cps; write for details.

SPECIFICATIONS—Chart paper: Grid width, 10". Length, 120 foot roll. Markings, 0-100, right to left. **Chart speed:** 2 inches per minute (standard); replacement motors for special chart speeds available. **Chart span:** Five fixed ranges: 10, 25, 50, 100, and 250 mv, plus a sensitivity control to permit adjustment for any value from 10 to 250 mv. Also external position available for special plug-in ranges. **Pen:** Standard fountain pen, cartridge type. **Balancing time:** 0.1 second per inch, 1 second full scale (10"). **Input circuit:** Easily modified with 5-pin connectors. **Error (includes dead zone):** Less than 1% of full scale for all ranges, 10 to 250 mv. **Maximum source resistance:** 50 K ohm. **Reference system:** Mercury cell. **Reference cell life:** 300 hours (approx.). **Power requirements:** 105-125 volts, 60 cps AC; 50 watts. **Fuse:** 1 ampere slow-blow. **Dimensions:** 13 1/2" W x 8 1/2" H x 13 1/2" D.

Assembled & Tested



\$135⁰⁰ EUW-19A

Heath OPERATIONAL AMPLIFIER SYSTEM

- Assembled, tested, ready to use
- Completely self-contained with built-in power and bias supplies
- Four operational amplifiers plus booster amplifier
- 5-pin amplifier terminals are accessible on front panel
- Amplifier balance controls provided
- Regulated DC+ & DC- power supplies with on/off switch
- Auxiliary power connector on rear apron
- Designed as part of the Malmstadt-Enke Instrumentation Lab

The EUW-19A is a self-contained operational amplifier system that is ideal for experimental work in research and development laboratories. It can be connected as a constant current source, a controlled potential source, a linear sweep generator, or as a servo-system simulator. Addition, subtraction, integration, and differentiation problems can also be programmed filling countless applications in measurement, computation and control work.

The amplifier system incorporates four high-gain operational amplifiers, a high current booster amplifier, and regulated +300 volt and -300 volt power supplies. One of the operational amplifiers can be front-panel switched to operate as an inverting amplifier, or as a follower amplifier. The booster amplifier is designed for power applications, such as driving motors, etc.

The 5-pin amplifier terminals on the front panel permit simple connection of spring-clip components used in the EU-13A Universal Experimental Parts group (described on page 41), or standard 5-pin sockets wired as plug-in adapters. Blank plug-in adapter chassis will soon be available. By constructing and connecting specific adapters the EUW-19A becomes a precision instrument for a wide range of scientific measurements—as well as being useful in computation and control.

The high-gain, low drift, and wide flexibility of this operational amplifier system represents an outstanding value in lab facilities.

EUW-19A... 18 lbs... no money down, \$13 mo... **\$135.00**

SPECIFICATIONS—OPERATIONAL AMPLIFIERS: DC gain, open loop: 8600 (9 ± 1 db); Frequency response: 3 db down at 45 cps; 6 db down at 100 cps. **Voltage range:** -50 V DC to +50 V DC at input and output with a 50 K ohm load. **Output current:** -1 ma to +1 ma with 50 K ohm load. **Output impedance:** 6700 ohms. **Phase shift:** Less than 1 degree at 25 kc. **Rise time:** 15 micro-seconds. **Drift:** Less than ± 8 mv/day under normal conditions after 48 hours, or more, aging period. **Amplifier 1 only:** May be switched for Follower or Inverter operation, also to provide + or - inputs. **BOOSTER AMPLIFIER:** Maximum output: ± 20 ma at ± 50 V DC. **Gain:** Approx. 5. **Output impedance:** 1400 ohms. **Power requirements:** AC input: 105-125 volts, 50/60 cps. **Filament power only:** 44 watts. **Total power required:** 94 watts at quiescent operating conditions. **Fuses:** Two 3/4 ampere slow-blow fuses; one for the filament circuits, and one for the DC+ and DC- supplies. **AUXILIARY POWER CONNECTOR:** Location: Octal socket on rear of unit. **Power available:** +300 volts at 20 ma and -300 volts at 20 ma with unit in operation. +300 volts at 60 ma and -300 volts at 60 ma when all amplifier tubes are removed. **Balance resistors:** Available at auxiliary connector to balance power supplies and adjust output voltages. **GENERAL:** Dimensions: 11 1/2" W x 6 1/2" H x 12 1/2" D.

Professional Lab Instruments A



Heath VOLTAGE REFERENCE SOURCE A Precision Lab Instrument at Tremendous Savings!

- Resolution .1 MV to 100 MV in four ranges
- 0-100 volts DC output—zener stabilized
- Potentiometer type operation—direct reading
- Polarity reversal switch
- Push-button zero switch
- Signal input position

EUW-16
\$65.00



The EUW-16 Zener-stabilized Voltage Reference Source is an extremely handy instrument for the modern electronics laboratory. The highly accurate voltages produced by this instrument can be used for precision calibration of other laboratory instruments or for accurate measurement of unknown voltages.

In the standard voltage position, voltage is variable from 0-100 volts DC for calibration purposes, for bias or zero-suppress voltages or for applications where current drain is low. It is not intended for use as a power supply. Accurate voltage measurements can be made in the "sum-diff." position, by connecting the unknown voltage at the input and a null detector at the output. Unknown voltage is then read directly from the panel dials.

A push-button switch permits fast check of Zero on the null meter or scope. Other features include a polarity reversal switch and a signal position that permits application of signal at output terminals for comparison or checking purposes. A minus (-5) position on the coarse voltage switch provides -5 to +5 mv, -50 to +50 mv, -0.5 to +0.5 volt, or -5 to +5 volts for applications requiring smooth control of voltages carried through zero.

EUW-16... 6 lbs.... no money down, \$7 mo. \$65.00

SPECIFICATIONS—Output voltage: 0-100 volts DC. **Resolution:** .1 mv on X1 range, 1 mv on X10 range, 10 mv on X100 range, 100 mv on X1000 range. **Accuracy:** ±1% or 0.1 mv, whichever is larger. **Readout:** Directly on three dials: Coarse Voltage, Fine Voltage, Range. **Controls:** Coarse Voltage; 0-100 mv, in 10 mv steps. Fine Voltage; 0-10 mv, continuous. Range; X1, X10, X100, X1000. Output Selector; Four positions: AC Ohm, Signal, STD Volts/ohms, Sum-Difference. Polarity Switch; NORMAL (SUM) position, or REVERSE (Difference) position. Pushbutton Zero; Shorts OUTPUT terminals together. Mercury reference cell and holder supplied for calibration. **Power required:** 25 watts, 117 V AC, 50/60 cps. **Fuses:** ½ ampere slow-blow. **Dimensions:** 5½" H x 6¾" W x 8" D.

Heath UNIVERSAL POWER SUPPLY Ideal for classroom and lab use

- Functions as full-wave, half-wave, bridge, or voltage-doubler supply
- Less than 10 millivolts ripple, jitter & noise
- Regulated B+, 200 to 350 volts DC @ 0 to 100 MA
- Unregulated output, 100 to 500 volts in five ranges
- Separate power & high voltage on/off switches

EUW-15
\$75.00



The Heath EUW-15 Universal Power Supply, as its name implies, fulfills many uses in design and research work. It is both a well-regulated power supply for general laboratory applications and an experimental unit that can provide many different types of power supply circuits. Fast, simple wiring changes, using spring-clip connectors permit selection of full-wave, half-wave, bridge, or voltage doubler supplies and various filter circuits that will fill unlimited applications in teaching and in electronic design and instrumentation work. The built-in load and the AC input voltage can be varied for studies of power supply stability.

A partial schematic diagram screened inside the chassis and on the bottom cover of the power supply, plus the quick-connect jumper wires furnishes aid in selecting the desired power supply function and filter networks required for any particular application. Five-way binding posts and octal sockets permit fast, easy connection for DC+, DC-, and filament voltages. A connecting terminal is also provided for easy connection of a milliammeter in series with the DC+ output. The many features and high versatility of the EUW-15 make it an ideal power supply for critical laboratory and teaching applications.

EUW-15... 15 lbs.... no money down, \$8 mo. \$75.00

The following specifications are for the EUW-15 Power Supply when it is wired for voltage-doubler operation. **SPECIFICATIONS:** B+ voltage output: 200 to 350 volts DC regulated, at 0 to 100 milliamperes continuous. Filament voltage output: 6.3 volts AC at 3 amperes. B+ regulation: Output variation less than 1% from no load to full load at 300 volts. Output variation less than ± 1 volt for a ± 10 volt variation in the AC line input. B+ ripple: Less than 10 millivolts rms ripple, jitter, and noise. B+ output impedance: Less than 10 ohms from 5-100,000 cps. **Divider voltage (unregulated):** Approximately 500 v, 400 v, 300 v, 200 v, 100 v. **Voltage divider:** Internal, using five 1500 ohm 10 watt resistors. ... also can be used as a variable internal load. **Tube complement:** 1-6L6GC series regulator; 1-6BH6 control amplifier; 1-OB2 voltage regulator. **Controls and switches:** Divider Voltage (or variable load switch); Divider—Regulator switch; Regulator Voltage (min.—max.) control; Power (on-off) switch; High Voltage (on-off) switch; **Output terminals:** DC+ and DC-. Filament (6.3 V.A.C.), Meter, Chassis ground. **Power requirements:** 105-125 volts AC, 50/60 cps, 85 watts. **Dimensions:** 8¼" W x 6½" H x 12¾" D.



EUW-17
\$20.00

Heath EUW-17 TRANSISTORIZED POWER SUPPLY

- Solid-state circuitry
- Output voltage variable from 0 to 35 volts DC
- Current output available up to 200 MA
- AC ripple less than .1% at full load
- Transistorized electronic filter
- Dependable silicon rectifiers

The Heath EUW-17 is a solid-state low-voltage power supply designed to furnish all operating voltage and currents for experimental transistor and other low voltage circuits. Output voltage is variable from 0 to approximately 35 volts DC no-load, and currents up to 200 milliamperes are available for a wide range of applications. A transistorized electronic filter provides extremely well-filtered DC voltage and is designed to withstand short circuits without damage to the unit itself. Ripple is less than 0.1% at full load. Dependable long-life silicon diodes are used in the rectifier circuit and the unit is fused for extra protection. Simple controls consist of on/off switch and variable output voltage control. A pilot light is provided to show when the unit is "on." Five-way binding posts permit easy connection to test circuit. Neat compact size measures only 4¾" H x 4¾" W x 4½" D. Ideal for laboratory or classroom use.

EUW-17... 3 lbs.... \$20.00

SPECIFICATIONS—Output voltage: 0 to 25 volts at maximum current, 0 to 35 volts with no current output. **Output resistance:** Less than 50 ohms. **Ripple:** Less than .1% at full load. **Semiconductors:** (1) R268A Transistor, (2) Silicon diodes. **Circuit type:** Full-wave rectifier. **Control:** Voltage, with on/off switch. **Power requirements:** 105-125 volts AC, 50/60 cps, 9 watts.

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Order the kits you need now... no money down, up to 18 months to pay on any purchase of \$25 to \$600. Established accounts may add-on purchases of \$25 or more with no additional down payment. Use this convenient service to equip your lab now!

See Order Blank For Details On Heath's Time Pay—No Money Down

Electronics for Scientists

*Principles and Experiments
for Those Who Use Instruments*

H. V. Malmstadt
University of Illinois

and

C. G. Enke
Princeton University

with the assistance of

E. C. Toren, Jr.
Duke University

W. A. Benjamin, Inc.

New York

1962

pedance (± 10 per cent), 10-volt range, 0 to 220 ohms; 1-volt and 0.1-volt ranges, 52 ohms. *Rise time*, less than $0.15 \mu\text{sec}$. *General*: Frequency accuracy, ± 5 per cent.

Decade Resistance Box. Resistance values from 1 to 999,999 ohms in 1-ohm steps available across terminals, $\frac{1}{2}$ per cent accuracy, 1-watt resistors.

Resistor Substitution Box. Resistors ranging in values from 15 ohms to 10 megohms available across terminals, 36 EIA standard 10 per cent, 1-watt resistors.

Capacitor Substitution Box. Capacitors ranging in value from 0.0001 to $0.22 \mu\text{f}$ are selected by 18-position panel switch, silver-mica and plastic molded capacitors in standard EIA values, rated at 600 volts with the exception of the three largest, which are rated at 400 volts.

Tool Kit. A combination midget wire stripper and diagonal cutters, midget long-nose pliers with plastic-covered handles, three screwdrivers ($\frac{1}{8}$ in. with 3-in. blade, $\frac{3}{16}$ in. with 4-in. blade, and $\frac{3}{8}$ in. with 3-in. blade and pocket clip), a Weller model 8200K Dual-Heat soldering gun, solder joint brush, a set of five nut drivers ($\frac{3}{16}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{1}{2}$ in.), a nut starter, and a combination metal two-way soldering aid tool.

S1-2 EUW-13. Universal Chassis and Parts

A unique system of quick-connect electronic parts and chassis is described in this section. With this system circuits can be constructed, tested, and modified in a small fraction of the time that would be required if soldered connections were used. Without this system it is impossible to complete the experiments described in this book in 15 afternoons of laboratory work. As an additional advantage, the parts in these circuits are connected by the "point-to-point method" just as they would be if wired permanently in a conventional chassis. Economy in time and parts is also provided, since all potentiometers, resistors, capacitors, leads, tube sockets, and other parts can be used over and over again. Also, any extra parts or components not already in the system can be easily connected into the circuits because of the versatility of the connectors.

Four years of classroom experience has proved this system to be a valuable aid in electronics instruction. It is also useful for circuit development in research and development laboratories. The circuits built with these rapid-connect parts can be used permanently, if desired, after they have been tested and optimized.

A simple circuit wired on an experimental chassis is shown in Fig. S1-1. It can be seen that a $\frac{1}{8}$ -in. post is used wherever a solder lug would ordinarily occur with standard chassis components. Wherever a wire would be soldered to a lug, a spring clip is used to make the connection to the post.

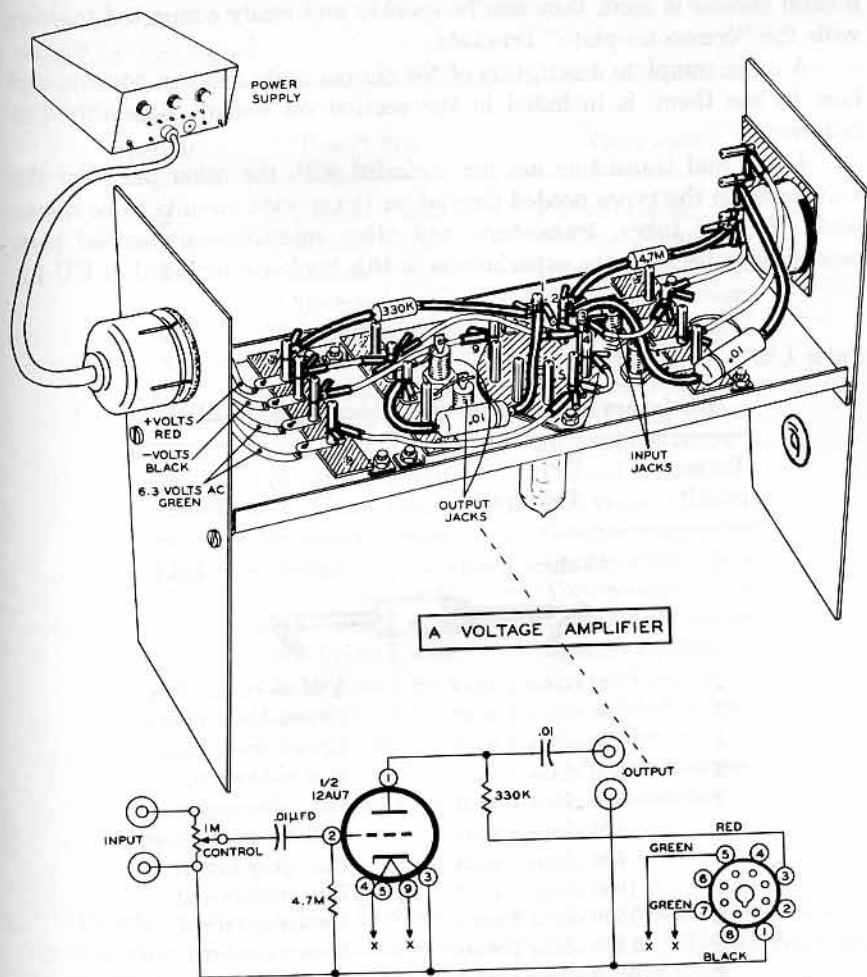


Figure S1-1

As many clips as necessary can be connected to each post. Resistors, capacitors, and connecting leads all have insulated sleeving and a spring clip on each end. The contacts have excellent electrical characteristics, and the circuit is wired in a very realistic way. The modular experimental chassis are designed and constructed with many convenient and time-saving features. One set of tie points are already connected to the power-supply socket and to input and output banana jacks. Therefore, test circuits can be rapidly and safely connected to the power supply, input-signal sources, and output-measuring devices. When more than one experi-

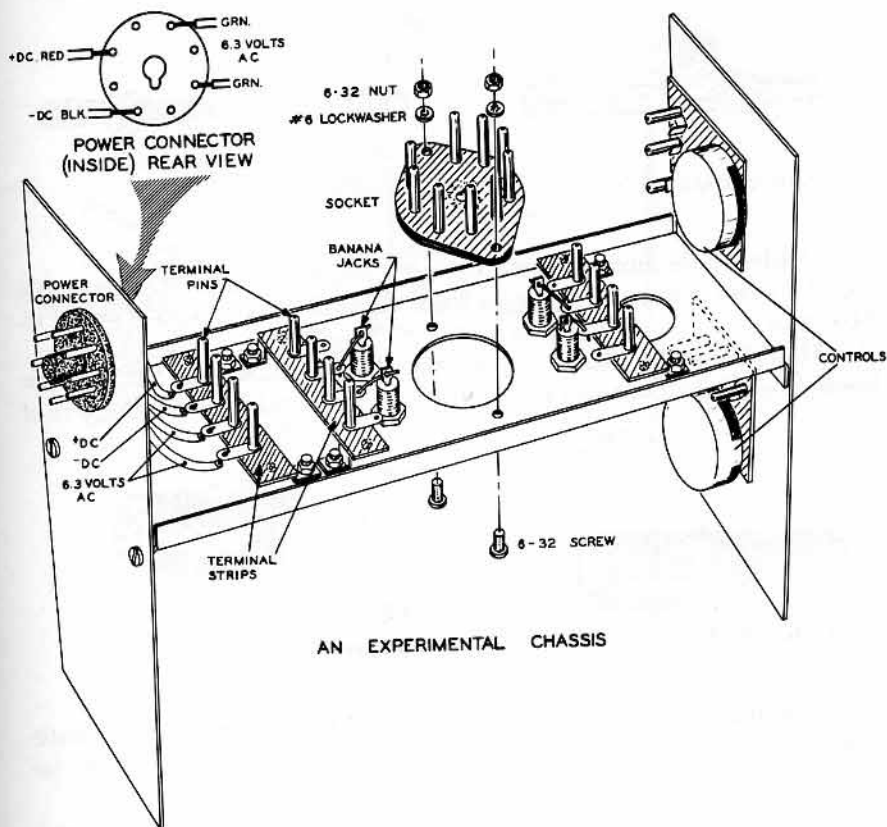


Figure S1-13

Hardware. Hardware for mounting interchangeable tube sockets and control potentiometers: twenty 6-32 \times $\frac{3}{8}$ -in. screws, twenty 6-32 nuts, ten control nuts, twenty No. 6 lockwashers, and ten control lockwashers (Fig. S1-14a to e, respectively).

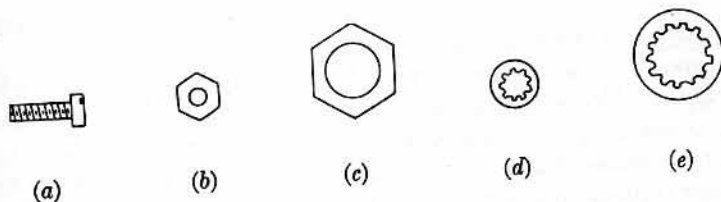


Figure S1-14