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CIRCLE NO. 12 ON READER SERVICE CARD
Check your Psi Quotient with this ESP TESTER!

YOU CAN RUN SOPHISTICATED TESTS OR USE THE MACHINE AS A SURE-FIRE PARTY GAME

DID you know that electronics technology is being used to confirm extra-sensory perception (ESP), among other psychic phenomena? Using digital logic, interactive displays, and computer programs, scientists are showing that:

- A possible link exists between business strategy and ESP.
- Mind may influence matter even at microscopic levels.
- ESP communications may be just around the corner.

The ESP tester described here is actually a random-number generator and a testing circuit that records and displays your hits and misses. It uses inexpensive TTL logic and a simple transistor as a random-noise source. Thus, your experiences with this device guarantee that the target selection is totally beyond any known physical effect and that recording error is eliminated. With it, you can actually conduct an unbiased investigation of ESP, as well as play some entertaining games.

In Parapsychology it has become standard to use a "two-tailed" distribution. This, in effect, doubles all probabilities. The reason it's called two-tailed is that both halves of the probability distribution are used rather
than one half. The decision to use two tails came about from strong evidence that constant variability, scoring below chance, is as valid an indicator of P(i) as constant hitting. In fact, even constant scoring at chance is evidence of P(i). Thus, not knowing the direction, P(i) might take, parapsychologists take the conservative route and double the resulting probabilities.

When is a score evidence of P(i)? Scoring
There is one additional technique becoming popular in analyzing for Pst. It's called the variance differential effect (VDE). Usually, the VDE gives us a way of measuring the resulting fluctuations in scores as they vary about the mean. For instance, look at these results from a test using the ESP machine with "a" on Item 0, 15, 16, and 8, 8, 8. In the first case, the scores vary quite a bit from the mean and have a large VDE. The normal analysis, however, would tend to cancel out the large variations and
Theory of Operation. Referring to the simplified block diagram of Fig. 1, a reverse-biased transistor junction provides the source of noise or randomly distributed frequencies. Such noise pulses are the result of unpredictable quantum actions inside the transistor and are considered one of Nature’s most elementary random processes. The randomness given us a non-deterministic number generator since there is no way we can predict when the next noise pulse will occur.

When either the “A” or “B” switch is depressed, two things happen simultaneously. A digital logic “1” is latched (stored) in the Q or Q of the flip-flop labeled A (depending on which switch depressed) and the noise pulses toggle flip-flop B a random number of times and leave it resting with a “1” in either its Q or Q. After all this action has settled down (50 milliseconds in our device) the contents of the two flip-flops are compared and if they are the same, you are given a “1” and the “more” counter increments by one (or else the display, if R5 turned on). If the contents of the flip-flops are different, you guessed wrong, and are given nothing (the counter stays the same).

The idea, of course, is to make the number on the display as large or as small as you can. An internal counter counts the number of switch depressions and after a preset number (16, 32, 64, 128), the “A” and “B” switches lock up and an “End of Trial” LED comes on. The number on the display can then be assigned a probability value.

With circuitry doing everything, but guessing, there’s no chance that the results are due to bias or skill on a strictly physical level. With some simple statistics, the results can be used to show objectively whether or not ESP—P.K. or precognition—is occurring.

Circuit Description. In the schematic of Fig. 2, along with the complete block diagram of Fig. 3, we can divide the circuit into seven parts: (1) the “A” and “B” switch inputs; (2) the random-number generator; (3) the memory which counts every switch depression; (4) the memory which counts the hits; (5) the display; (6) the automatic reset flip-flop and LED’s; and (7) the power supply.

Depressing S1, the “A” switch, causes a multivibrator R12 to go high (logical “1”) for 25 milliseconds. This “on” time is controlled by R3 and C3. Likewise, depressing S2, the “B” switch, causes mono

---

**Fig. 3:** Complete block diagram of the ESP machine showing how the various circuits interact.
IC4 is set high for 25 milliseconds. If SI were present, causing IC2 to go high, then a high is stored in the Q of flip-flop IC3B. If SI were present, the high is stored in the Q of flip-flop IC3B. A signal to either input of IC3A does three things: it causes flip-flop IC3B to latch it, causes flip-flop IC4A to un latch it, and it causes IC3, the third reversible, to trigger. During the 25 milliseconds that flip-flop IC3A is unlatched, three pulses will cause it to toggle a random number of times, leaving the Q or Q' with a logical "1" in it. Because the clock input receives a burgers of random noise, there is no way the system will favor a particular state.
CONDUCTING AN ESP EXPERIMENT

The main aim in ESP is finding out what happens. With the ESP, one may discover which people have the ability to influence random events, and by rating how they score in the experimental studies, one can draw some interesting conclusions.

Obviously, one cannot use the number at tests performed, the score, and the results of those tests to prove a theory. Indeed, the most interesting results, it seems, are the results obtained under the most testing conditions. Parties make an especially good setting for wrapping out the machine.

A good run, one that will show marked differences, might have "A" set to 10 and "B" set to 10. Each trial would then be 28 or 16, totaling 464. The 28 times a "B" moves into quarters is an average score, but it is better, being higher than expected. You can average seven runs in each condition, so we have six runs completed.

Tell the participants that the device is an electrical brain trigger and the idea is to guess how the "Brain" will be pressing either an "A" or a "B." Since they don't know what the device will do, it is a fair trial. The purpose of the trials is to check the validity of ESP experiments.

Other Uses for the ESP Machine

One can find all kinds of uses to use the ESP machine. For example, it makes an excellent home entertainment game or device if the display switch is used. By shutting off the display, the machine can compete at answering the cards. Here's just a partial use of games to use your imagination for others:

1. High score win. Flip switch off. Stop after 30 is reached, that is, after half a year.

2. Low score wins. Like above, but going for the low score.

3. Closest win. Flip switch off when each score of the person coming closest to choose prediction wins.


The outputs of KCA and KOD, the two flip-flop's, are monitored by IC5, an exclusive or configuration of seven gates. According to the truth table for exclusive or, only combinations between outputs will give an output, that is, if both O's are a "1" we get an output or if both are "0" we still get an output.

Therefore, after 25 milliseconds, the flip-flop with the logic has been equalized about 1,000 times, the output of the exclusive or has gone high every time a coincidence occurred, and it is now testing with its output high or low. Now we need some way to convey to the "Brain" memory whether we have a hit or a miss. IC8 as a mono used to lock up the display while the random numbers are being generated. It does this by sending a low to gate IC70 for 25 milliseconds when it is triggered by the "A" or "B" switch. Now, 25 milliseconds after the exclusive or has made its comparison, IC5 goes back to its normally high state. If the output of the exclusive or gate is high, then IC60 will go low when this mono returns high. This is a "hit" condition and causes the memory output, IC9 and IC10, to go up at once output. If, however, when IC8 goes back to being high, the output of IC60 is low, then the output of IC60 will either go high, or stay high if it was previously. Both conditions trigger a "Miss" and don't affect the counter. All these operations take place within 50 milliseconds, which is about twice as fast as any other way you can hit the switch.

No measuring has been made for pressing both switches together and it isn't recommended. There is no real reason to press the switches at high speed anyway.

We need some way to show when a cer-
The operation of the switch is as follows: The "Start" LED goes out and the "Play" LED comes on. At the same time all the counters are reset to zero and the operator for another run. If at any time within a run you want to start over, simply hit the "Resume" button.

The noise source consists of a reverse biased transistor emitter-base junction. The transistor used in the prototype was 2N2712 which has a reputation for breaking down easily; however, a 2N2712 will do in this. Out of five units four worked. The ultimate frequency of the noise pulses will depend on the bandwidth of the amplifier through which they pass. In this circuit, the overall frequency is about 100 to 70,000 Hz. At 70,000 Hz, and with a 25-megohm sample period, the flip-flops will be toggled about 1000 times. This is fast enough to guarantee a high degree of randomness. R19 sets the bias point of the Q1 collector which runs on C7, along with R17 and C8. Slow any 170-ohm to the power supply from entering the noise source. IC13, IC14, and R17 are the non-inverting amplifiers, each with a gain of 10. Noise from the diode junction reaches about 5 volts peak-to-peak at the output of IC13. From here, the noise signal is rectified to remove

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**Fig. 4. Schematic of power supply. PCB board construction is suggested.**

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negative components and feed to Q3 where it is converted to the 5 volt logic level.

The power supply consists of a series-pass regulated stage for the 5 volt logic and a non-regulated ± 8 volts for the op-amps. The transformer in the supply may get hot unless adequate ventilation is provided.

Construction. Building this circuit is easier if you do it in sections. Circuit boards are almost a "must," since wiring could be complex. The circuit is split into two sections: the logic fan circuitry, for "hits" counting, and the linear amplifiers are all on one board, along with the power supply. Another board holds the two-digit display and "Hits" memory, along with the indication LEDs.

Begin by building the power supply (Fig. 1). After all parts are in place you should test the supply with a 20-kohm load resistor. Ripple should be less than 10 millivolts peak-to-peak. Next build the ± 8 volt supplies, along with the noise amplifiers. The output of the noise amplifiers should oscillate between 0 and 5 volts.

Next, install the logic circuitry and the twelve jumpers, being very careful of pin locations on the IC's. Use the parts layout guides shown below to get the various components in the right places.

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</table>

After finishing the logic board, move to the display board and install all of its components, followed by jumpers and then LEDs. Test to see that the display will react by grounding the reset input after feeding it some counts. It should return the display to zero.

Finally, hook up all switches and you are ready to go. A professional-looking panel can be made of smoked plexiglass.
How It Works. The circuit used to detect the temperature difference is shown in Fig. 1. Essentially, it consists of an operational amplifier (B.C.) whose output state is determined by the voltage drop across a pair of germanium temperature-sensing diodes, D1 and D2. This voltage drop is dependent not only on the current flowing through the diodes but also on the ambient temperature surrounding them. The integrated circuit is connected as a differential amplifier whose output is coupled to a Schmitt trigger consisting of Q7 and Q8.

The trigger circuit converts the relatively slow action of the output of the op amp (due to the slowly changing voltage across the diodes) to a fast-acting switch. The trigger, though an inverter, does not change the frequency of operation. Since such a circuit is regenerative, its action is fast, and slow input signals become sharp, decisive outputs.

Although it is possible to connect the motor control relay to the collector circuit of the Schmitt trigger (Q8), some added
working margin is included by using the trigger to drive a limited power stage, Q2, which has the relay in its collector circuit. The emitter of Q3 is biased by R15 and base drive Q2, so that Q4 is either on or off. When the positive-going signal from Q2 occurs on the base of Q4, it turns on very fast, energizing the relay.

The amplifier compares voltages across the two diodes, D1 and D4. Diode D1 acts as a safety diode if the circuit happens to have power applied when D1 is not in the circuit. This is necessary to protect the op amp. Feedback resistor R7, in conjunction with the 1000-ohm input resistor produces a stage gain of 1000 in the op amp. To reduce temperature sensitivity, R7 can be replaced by a smaller resistor to reduce circuit gain.

Zener diode D2 clamps the input circuit at 6 volts, were the op amp cannot accept either over ground or below 0.2 volts. Most operational amplifiers do not have this problem as they are operated by either a positive or a negative supply.

Diodes D1 and D4 should be as alike as possible and should be checked by measuring their forward voltage drop. This is done by connecting a resistor in series with the diode and power source and measuring the diode drop very carefully. Final adjustment
Construction. The circuit can be constructed on perf board or a printed circuit board. There is nothing particularly critical about the circuit. Diode D4 is mounted on the circuit board in such a way that its case simulate around it. Diode D4 is mounted outside the basement window and connected by a length of ordinary two-conductor cable. Do not place D4 where it will get direct sunlight, since the excessive heating will produce false results.

The mechanical arrangement is shown in Fig. 2. A suitable length of 6" stovepipe with an elbow is the main element. The axial fan is mounted at the end of the stovepipe at shown and the entire assembly is suspended so that the fan is at the window. Remember it exhausts the basement air and the bottom of the stovepipe is about 1" from the floor. Keep the electronic circuits, especially D4, at least two feet away from the bottom of the stovepipe so that the moving air will not cool the diode and produce a false indication in the differential circuit.

Calibration. With D1 and D4 close to each other, allow them to stabilize for an hour or so. Then set R3 a little bit beyond where the relay opens. The two diodes are now temperature matched. If a large fan is required, and the current demand is more than the KT contacts can tolerate, use KT to drive a power relay or a simple SCR or triac controller.

The electronic circuit for differential temperature sensing can be easily assembled on a breadboard as shown here. It should be positioned two feet from pipe.
Build a
WHEATSTONE BRIDGE

999,999 Resistance Values
to Measure or Substitute

BY CONSTANTINE GALLAS

ELECTRONIC EXPERIMENTER'S HANDBOOK
A PC board, mounted directly on meter terminals, is used to hold two bridge circuit resistors as well as prusa connection points for the circuit wiring.

Here is a versatile project that will serve the experimenter or technician in two ways: it can be used as a test instrument to measure any resistance value from 1 ohm to 1 megohm; and it can provide substitute resistors over the same ohmic range to be plugged into any circuit.

McBryde's "Law of Resistors" states that you never have the value of resistor needed to be a particular circuit and that when measuring a resistance value (using a VOM), the needle inevitably goes to the crowded, difficult-to-read end of the scale.

If you have these problems, you will want to build the substitution Wheatstone bridge/resistance substitution box described here. At the tip of a switch, you can get resistance substitution values from 1 to 999,999 quite a few parts. As the schematic in Fig. 1 shows, this instrument has only four resistors and four split switches in each decade. Not only does this requirement minimize wiring, it also means that construction is simplified.

Note that the resistors in each decade are in a 1, 3, 9, 27 arrangement. Thus in the first decade, you can obtain any value from 0 through nine by switching to the required value and shorting the others out. The same is true of all the other decades. Since the decades are in series, values from 0 to 999,999 are obtainable.

The Wheatstone bridge, whose simplified schematic is shown in Fig. 1A, is an electronic balancing circuit. If $R_c$, $R_s$, and $R_0$ are known, then $R_m$ must have a resistance such that there is no voltage difference between points A and B in order to get a null indication.

SUBSTITUTION BOX

In this one-dial type of you can measure precisely the value of an unknown resistor within the same range.

Conventional resistance substitution boxes have nine resistors and 10-position switch for each decade. For six decades, a total of 54 resistors and six switches is required.
until the meter reads zero and reading the resistance of R₁.

As shown in Fig. 2A, potentiometer R₂ controls the voltage applied to the bridge and provides a means of increasing or decreasing the sensitivity of the meter. The direction of meter movement is determined by the respective polarities of the meter and the battery. When the instrument is complete, attach a known resistance to terminals 11 and 12 and determine the direction of deflection caused by too much or too little resistance. It is customary to make the left side of zero “too little” (or “under”) and the right side “too much” (or “over”). Mark the meter to indicate which side is which. The scale isn't done yet actually have to be marked except for an indication at zero.
Any-size-zero-center-microammeter may be used and the meter scale may be left "as is," or marked as "over" and "under" on the right and left sides. The meter scale divisions are not used.

**Construction.** The prototype was assembled in a large plastic case as shown in the photo. With the 24 switches mounted on the front panel, the precision resistors are connected directly to the switch terminals. In the prototype, the sensitivity control $R57$ and the bridge power switch $S25$ were mounted on the top of the cabinet with all other controls on the front. The battery is clip-mounted inside the chassis and the two

---

**Fig. 2.** The classical Wheatstone bridge is illustrated at A, while B shows how it is created in the bridge-substitution box project.

---

The bulk of the work is in cutting the holes to mount the 24 switches in the selector circuit. Be careful when drilling plastic as it shatters very easily. If there is any doubt, use a metal cover for the plastic container.
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CIRCLE NO. 6 ON READER SERVICE CARD

LECTRONIC EXPERIMENTER'S HANDBOOK
Solder & Soldering

How to make reliable soldered connections and insure that your circuits will perform.

BY DENNIS BERNIER
Director of Research & Development
Kester Solder Division, El逢ton-Rossetter, Inc.

In electronic assemblies, solder is used to join metals more often than any other type of fastener. While much thought is usually given to choosing the correct electronic components and circuit layout, too often little attention is paid to choosing the proper soldering materials and learning the techniques for making reliable soldered connections. The failure of an expensive piece of electronic equipment can frequently be traced to a defective solder joint, a costly error made by an assembler with an inadequate understanding of soldering principles.

Soldering of electrical connections involves both theoretical techniques and practical experience. The science of soldering metallurgy and the chemistry of fluxes are carefully researched in solder manufacturer’s laboratories, resulting in high-quality products for every soldering application. The use of soldering materials should be based on the requirements for making reliable soldered connections and developing the necessary skills in using the proper solder, flux, and soldering equipment.

The word “solder” is derived from the Latin “soldera,” meaning “to make firm.” Self-soldering refers to joining metals at temperatures below 200°F, a low enough temperature to allow the use of simple tools and easy-to-learn techniques.

Solder Alloys: Although there are hundreds of solder alloys made from many different metals, the most common solders consist of a mixture of tin and lead. Fig. 1 indicates the melting point (solidus) and flowing point (liquidus) of several compositions of tin and lead.

When the solder is added to lead, or lead to tin, the melting point of the original metal is lowered. The 60-40 tin-lead composition is called the eutectic alloy since it melts and flows at the same temperature (361°F). The other tin-lead alloys melt with a “plastic range,” where the solder is not completely melted and is in a pasty condition. The high-lead-content alloys (50-100%) are applicable in the plumbing industry because these alloys can be used to fill wide gaps. For electrical soldering, however, only the alloys near the eutectic composition...
(636-46) have the required low temperature and wetting properties.

Other special alloys are used, for instance, when soldering to silver, a solder with 25% silver can be used to prevent silver from dissolving into the solder. The choice of alloy is also dependent on the soldering temperature. It is recommended that soldering be done with the lowest melting solder alloy possible, to avoid heat damage to electronic components. Fig. 2 indicates the most common solder alloys and their melting temperatures.

Metal Solderability. Solderability is simply defined as a clean metallic surface. Removal of all dirt from surfaces to be soldered is essential. The soldering flux will remove only oxidation. Other dirt, such as wax, oil, grease, or epoxy on component leads, should be removed prior to fluxing and soldering.

Metals which do not solder, like gold and platinum, are the easiest to solder. But, because of their high cost and rapid dissolution in solder, these metals are best avoided for soldering. More common solderable metals used in making electronic components are copper, brass, nickel, chromium, tin, and solder-plating. All of which form oxides or salts which a mild flux can remove.

Soldering requires that the actual solder deliver small amounts of the solderable metal, such as copper, and form a new intermetallic compound between the solder and the solderable metal. This intermetallic layer is what holds the solder joints together.

Soldering Flux. When a metal surface, like copper, is exposed to air, the oxygen in the air will tarnish or oxidize the copper surface. This oxidation occurs even more rapidly when the surface is heated. So, the soldering flux must be able to remove a small amount of oxidation already on the surface and prevent oxidation during heating. Only a clean surface is a solderable surface. When the solder melts at elevated temperatures the heated metal surface must be clean for the solder to bond properly. The flux causes the solder to wet and spread out on the surface.

There are three types of flux: inorganic acid, organic, and resin. For most electronic soldering applications only the resin or resin-acidified rosin types can be used since the other types are acidic and tend to oxidize. Liquid fluxes are used for automated soldering or to assist in removing stubborn oxides when hand soldering. The most effective solder for hand soldering is one with a flux cover. During rapid heating with the iron, the flux and solder are introduced to the joint simultaneously to complete the connection. The inorganic acid flux is preferred because of its improved residue-removal properties. For most applications, the resin and resin-base fluxes which leave residues that are hard, non-conductive, and non-corrosive, need not be removed after soldering. If removal is desired, a flux-removal remover is recommended for the job.

Soldering Technique. Besides choosing the best soldering materials, care should

ELECTRONIC EXPERIMENTER'S HANDBOOK
New tools you should know about

Now Teflon coating on saws
A new and tougher Teflon coating, now used on cookware, is now being baked on a full line of Disston hand and pruning saws to make sawing easier than ever. Called Teflon S, this new coating by Du Pont allows your saw to glide through both tough and wet wood without binding. Blade remains clean, has life-long protection against rust or corrosion and can be resharpened without affecting Teflon action. H. K. Porter Co., Inc., Pittsburgh, Pa.

Low-cost orbital sander
Ball bearings on the driving plate of Thor's new orbital sander provide a guarantee of long, trouble-free service to both the home workshop and professional. UL industrially rated, this sander takes a 4½x5½-in. abrasive sheet which allows you to cut three strips out of each standard 9x11-in. paper. Priced to sell for less than $15. Thor Power Tool Co., 175 State St., Aurora, Ill. Thor is also introducing a new two-wheel bench grinder with shaded-pole motor for $18.88.

Slimserts replace stripped threads
Stripped threads are no longer the aggravating problem they used to be. Now you need simply to drill out the old hole with a step drill, then repet it end turn in a threaded Slimsert that fits the original bolt. Made of stainless steel, these screw-type inserts come in sizes from No. 10 through ¥1 in. in both U. S. (coarse) and SAE (fine). Proto Tool Co., Los Angeles, Calif.

Pressure roller speeds painting
Equipped with its own 1-qt. paint container, this trigger-fed roller makes painting simpler than ever. Paint is forced through perforations in Dynel roller for continuous, even application. A special enameling sleeve slips over the Dynel one for an ultra smooth finish. Extra handy for boat painting. Sells for $12.05 from Warren Pressure Rollers, 3315 Southwest Drive, Los Angeles, Calif. 90043.
then top and bottom are screwed on.

The tilting motion for the launching end consists of a 3/4-in. dowel clamped tightly in a split block. Tilt the block just enough so that the rod will turn but will hold in any position. This way, you can tilt the rod and it will stay until you move it. Half of the block is screwed tightly to the case and the other half in free to adjust pressure on the dowel.

For firing power, a 6-volt lantern battery is connected inside the case. However, if you prefer, you can also use four regular 6-volt flashlight batteries wired in series to provide 6 volts. Two wires with alligator clips on the ends are run through the launching channel for connection to the rocket's ignition wire. To keep the blast out of the guide slot, a small disc of metal with a hole in the center can be slipped on the rod. This will slide with the rod without hampering its tilting feature.

**Connecting the control**

The portable control box contains two normally open pushbutton switches and a pilot light. The circuit is arranged as such:

(Plotted on the page)
by a special Nichrome wire, supplied with must receive, that heats to a glow when connected to a battery.

The remote-control launcher shown here is to the gun and safety, by allowing you to set up at rest on the pad and then move well away from the actual firing—just as big rockets are launched. The battery is built into the launcher's base, and the remote-control box is connected to it by 25 feet of wire. A close supervision control eliminates any chance of firing the rocket accidentally. You have to have both buttons pressed in the same time to complete the circuit.

The launchers are used to hold and guide a rocket during the initial lift-off stage, thus a novel tilting feature that enables models to be fired at an angle as well as straight up. For easy handling, the remote-control box stores in the side of the launcher, and its wire is rolled neatly around the base.

While any rocket can be used with the launcher, the model suggested here provides a lot of exciting action since it's designed for parachute recovery. At the height of its flight, an electric charge blows off the nose cone, a miniature parachute pops out, and the rocket floats gently to earth. Just under a foot long, it's a home-baking, yet simple, design that's easy for a beginner to tackle.

**Making the launcher**

The launcher is topped with a 10-in-square aluminum plate to protect the wood from the rocket's blast. The sloped end the tilting guide rod can be cut with a metal-cutting blade in a saber saw or by drilling a series of /4-in. holes and filing out between them.

The full-length aluminum slope gives the launcher a pleasing appearance but is not absolutely essential. If you prefer, you can fasten a smaller piece of metal, such as a Teller-can lid, in the center of the launcher to catch the blast.

Close the plywood top and bottom pieces together and drill holes at the same time for all holes that line up. The sides are assembled as a unit first to form a
4. EJECTION CHARGE
RELEASES NOSE CONE

CONTROL BOX
STORAGE

LAUNCHER

ROD BLOCK

PARACHUTE OPENS AND ROCKET FLOATS TO EARTH
Getting started in model rocketry

Here's how to build a battery-operated launcher, a remote-control firing station and a solid-fuel ship to make this modern hobby safe and exciting.

By Eugene Florida

Teaching aid by Carl Levenson. Illustration by DCC Associates Inc.

All over the country, dads are helping sons build model rockets for the same reason they used to monopolize their youngsters'组织 trains. The fact is, for any age, there's a lot of thrill and challenge in fashioning a slim, gleaming needle-nosed projectile and watching it streak skyward in a fiery blast of its engine.

Today's model rockets come in a fascinating array of types and sizes. They're safe when handled with care and are readily assembled from kits and parts sold by hobby shops and mail-order houses. The rocket engines are simple cardboard tubes filled with a solid propellant that ignites like a cartridge in a gun. Depending on the size of engine used, model rockets can reach altitudes of 1000 feet or more. The propellant is ignited electronically.
the speed adjustments of the carburetor (though most of them are "fixed" in today's engines).

If sediment, gum or varnish are present on carburetor parts, the carburetor should be taken off the engine, dismantled and thoroughly cleaned in solvent. Replace dirty fuel filters and make sure the needle valve seat is seating in its seat.

Also, check the float level even for proper clearance as called for by specification. Usually, correct float level causes adjustment with a distance from the face of the shoulder to the tip of the needle valve 1.5/15 in. This check is made with the cover inverted. With the needle in the upright position, the distance between the lever edge should be 0.15/15 in.

Be sure to check the float level. If determined or saturated, replace it. Most floats have a spring that controls the needle valve. Too much can be seriously adjusted, usually by 0.15/15 in from top of float to end of spring.

With the float in place, make sure it spins freely. If anything is restricting the movement of the carburetor float, flooding will occur.

Finally, replace all gaskets with new ones. Carburetor gaskets have a tendency to swell in time, which impairs carburetor action.

Other parts of the fuel system that should be checked are the fuel pump and fuel lines. Leaking or restriction here impedes fuel flow.

**Tighten everything**

Finally, make sure all screws are rightly assembled. Any leaking is through the base of the carburetor or some other attachment area will obvious the inch and stop the engine of power.

There is only one type service area that should be examined—the cooling system. An engine required for extra heat demands complete, accurate cooling.

Don't let the owner and disassemble the water pump. Make sure impeller, water film and all seals are in good shape and not worn or damaged.

While you're in the engine area, check out gears and bearings. Take a look at the prop and prop shaft. If the shaft is bent, for example, you're not going to get full speed.

Once you've completed the tune-up, the engine is ready to go. From here on, it's up to the skipper, the boat and you.  

---

**Outboard Clinic**

Q. Try this one. A 1955 9-hp Johnson that runs and misses at any speed. Checked the plugs at the end of a day and found the lower cylinder plug gas-touched. A mechanic suggested a hotter plug. What do you think—C.D., N.C.

A. I think that every outboard engine should be run with the plug specified by the manufacturer and no other. Using a hotter plug is fine giving a day's worth for a toolknife—I'd remove the plug but it won't set any of the decay. As for what's causing the fouling, check the fuel valve feeding the lower cylinder to see if it's off its seat. If not, could be that an ignition breakdown is providing too much spark to burn the mixture fully. If so, it's time for a full tune-up.

Q. I'm ready to look for water in mine unless you can help. It looks back when I go to start it and get balks into the lower unit—J.P., Fair.

A. There are only a few things that could cause this condition in an outboard. The problem of location; the output isn't as difficult. As you might think. Check for spark plug wires rotated. If used any testers, timing and synchronization way out of wack, which can be cleared by either broken or not seating properly. After tracing down the problem, give the engine a careful tuning to make sure everything else is okay.

Q. I own a 1957 Johnson 14-outboard which is in good shape. It runs great at high speed, but it's trouble is that it won't idle. Can you help me with—C.A., Pa.

A. There are many reasons why an engine will refuse to idle properly. The major cause may be any of the following: Oil low in water, jet, and oil in fuel. The problem is improper pumped or water. Spark plug improperly gapped, or dirty. A tune-up should take care of the problem. If not, you'll have to start checking for a major problem like open valve, and sticking seats.

**FOR PERSONAL REPLY:** In your newsletter about the Johnson, I wish to add, "The Clinic" is the name in popular mechanics. 701 Lexington Ave., New York, N.Y. 10022. Enclose 25 cents in coin.
be taken to use a soldering iron which applies the right amount of heat. The key word is fast and not temperature. The proper size soldering iron tip will have enough mass to rapidly heat the connection so that the flux-core solder can be applied before excessive radiation has built up on the metal surface. Too high heat will cause a cold solder joint, a case where the solder has welded before the base metal forms the proper bond. Too much heat on the other hand, may cause the solder to form a thick an intermetallic layer, creating a brittle joint.

A soldering iron tip should be kept clean at all times. The tips should have a coating of molten solder. A copper tip will disintegrate, and eventually wear away, depositing resalting with a tip and ruining tip is often complicated to remove from the core; but an iron-plated iron is more difficult to keep clean than an all-copper one.

One common error is applying the hot solder to the hot soldering iron tip. This procedure burns away the flux below the solder melts, thus preventing wetting of the metal being soldered. The hot work...

### Table: Melting Temperatures of Common Solder Alloys

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Melting Temp. (°F)</th>
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<td>60/40 tin/lead</td>
<td>300-330</td>
</tr>
<tr>
<td>63/37 tin/lead</td>
<td>330-350</td>
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<td>90/10 tin/lead</td>
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<tr>
<td>40/60/10 tin/lead</td>
<td>430-440</td>
</tr>
<tr>
<td>85/15 tin/antimony</td>
<td>450-460</td>
</tr>
<tr>
<td>95/5 tin/antimony</td>
<td>470-480</td>
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</tbody>
</table>

Fig. 2: The most common solder alloys and their melting temperatures.
EVERY electronics hobbyist and service technician needs a bench power supply. To obtain best results, the supply should be completely variable from zero to the maximum voltage used in experiment circuits (usually 30 volts), and be capable of delivering enough current to handle normal loads (at least 1 ampere). In addition, the supply should have excellent regulation (both with power-line variations and load changes), minimum ripple and noise, automatic current limiting, and provisions for avoiding damage in case of inadvertent shorts.

The power supply described here meets these requirements. Its output is 0-30 volts with a line or load regulation of 0.025 or 1 mA; 0-12 A with line or load regulation of 0.25 or 1 mA. Transient recovery time is less than 25 microseconds, and ripple and noise are less than 0.25 millivolt rms. Cost is less than $85.

Theory of Operation. The complete schematic of the power supply is shown in Fig. 1. However, its operation can be better understood by referring to the block diagram in Fig. 2. The ac power is applied...
Fig. 1. The use of a special integrated circuit gives this power supply its excellent electrical characteristics. Circled letters indicate connections to board if you decide to duplicate prototype.

PARTS LIST

C1—1,000-pf, d.c.-equivalent capacitor
C2, C3—0.1-µF, 50-volt paper capacitor
C4—1000-pf, d.c.-equivalent capacitor
D1, D2—1N4002, 1N4004 diodes
D3—1N4002, 1N4004 diodes
G1, G2—2.0-µF, 300-volt paper-protected capacitor
G3—10-µF, 500-volt paper-protected capacitor
C5—500-pf, 50-volt paper-protected capacitor
C6—0.01-µF, 300-volt paper-protected capacitor
R1—100-ohm, 1-watt, 5% resistance
R2—10-µF, 125-volt electrolytic capacitor
R3—470-ohm, 1-watt, 5% resistance
R4—470-ohm, 1-watt, 5% resistance
R5—33,000-ohm, 2-watt 1% resistor
R6—2200-ohm, 1-watt, 5% resistor
RECT1—Bitter rectifier (Cox L524)
S1, S2—0-watt switch
T1—Power transformer, transformer 30V 2.25 at 1.25 and 0.15 at 0.15 A (Hewo #101-666)
W1—Variable resistor, 100-ohm (Hewo 2D61553)
W2—Variable resistor, 120-ohm (Hewo 2D61553)
R1—Dual converter control, 30,000,000 ohms
R2—22,000-ohm, 1-watt, 5% resistor
R3—10,000-ohm, 1% watt 2% resistor
R4—1,000-ohm, 1% watt 1% resistor
R5—220,000-ohm, 1-watt, 5% resistor

Note—The following are available from B&K Inc., P. O. Box 1766, Salem, N. H. 03079. 25A power supply (PS30A) at $15.00; 15A power supply (PS30B) at $16.25; 10A power supply (PS30C) at $19.50; transformer (PS30A) at $19.50; complete kit of parts including all hardware, accessories, over board, etc. (PS30K). at $19.50.
Fig. 2. In this block diagram of the supply, all of the functions enclosed by the dashed lines are contained within IC.

to transformer T1, one of whose secondaries supplies bridge rectifier RECT1 and filter C3 to provide unregulated dc for the overall regulator. The other secondary supplies rectifier DI and filter GT to create the dc power required by the reference voltage regulator in IC.

There are five functional circuits in IC. In addition to the reference voltage regulator, they are a constant-current supply, a voltage-controlled amplifier (VCA), a current-controlled amplifier (CCA), and an on-gate transistor Q1 is an amplifier.

Fig. 3. These are actual-size foil patterns of the printed-circuit boards. They can be made of 2 oz. epoxy glass.
driven by the output of the op-amp and Q2 is the main series pass regulator.

The reference voltage regulator provides a stable reference voltage for the constant current portion, against which variations in other parameters are compared. The VCA functions as a voltage-controlled sensing amplifier. One input to this differential amplifier is connected to the positive output of the supply, which is compared to a reference voltage derived from a known current passing through a variable resistance (the voltage-controlled potentiometer). The current resistance of the potentiometer multiplied by the known current flowing through it determines the reference voltage. Since the VCA tries to maintain the voltage between its two inputs at zero, any difference between them produces a change in the VCA output, thus causing either an increase or a decrease in the drive to Q2.

The CCA operates in a similar fashion, except that its inputs are derived from either side of a current-sensing resistor (R4). Therefore, any difference between the voltage set by the current-control potentiometer and the voltage across R4 causes a change in the output of the CCA to increase or decrease the drive to Q2.

The op-amp determines whether the voltage or current control sets the output of the power supply. If either the VCA or CCA calls for a change in drive to Q2, then that amplifier is in control. Output amplifier Q2 provides the necessary gain to drive Q2.

**Fig. 4.** How components are mounted on boards. The small one goes into the edge connector on the box board.

**Fig. 5.** Completed boards should look like these. The two dual potentiometers mount big board to chassis front.

**Construction.** The power supply can be assembled in almost any manner, but the "mother-daughter" PC board approach used in the prototype represents an easy assembly procedure and also allows for variations in the circuit I desired. Full patterns for the two boards are shown in Fig. 6. They should be Edisolced on 2 oz. epoxy-glass board and mounted by a 10-pin edge connector.

The components are installed on the boards as shown in Fig. 7. The layout of the large board is such that several parts are provided for the sound construction of some components to allow for variations in size among manufacturers. Observe the potentiometers, capacitors, and resistors. Dual potentiometers R1 and R6 should be mounted close to the signal before soldering since they provide support for the lead end of the large board. Clip off the excess potentiometer terminal lengths after soldering. The completed boards are shown in Fig. 5.

The boards and other components are
mounted in a suitable chassis as shown in the photograph. The heat sink for Q2 is mounted on the rear apron using thermal insulation (foam, rubber, etc.) between heat sink and metal chassis. When mounting Q2, use generous amounts of silicone paint and the manufacturer's provided with the transistors.

The photographs show how the various controls, the meter, and output jacks are mounted on the front panel. Remember that the 60-pot omega controls do not support the control board (with spacers and mounting hardware). The line cord is brought out through a grounded hole in the back of chassis. The large black capacitor (C3) is soldered in a clamp mounted on the chassis, while the power transformer is mounted along the back of the chassis.

The scale of the meter must be calibrated to indicate from zero to 35 volts with each 5-volt step identified. On the current scale, each 0.1-ampere step should be marked from zero to 1.2 amperes.

Checkout and Use. Before putting the supply in operation, test all wiring and interconnections. We especially carried with (12) making sure that it is insulated from the heat sink and chassis, and that it is properly connected.

Turn on the power and set S2 to the right position. Set the constant-current

controls (RE), to about 120, and notice the coarse-control voltage controls (B1-B3) noting that the meter indicates between zero and approximately 30 volts. Place S2 in the up position, short the output terminals (B1 and B3) and note the current controls. The output current should vary between 1.2 and 1.4 amperes.

Set the current control about midway, remove the short between B1 and B3 and connect a 15-ohm, 30-watt resistor across the output terminals. Place S2 in the up position and slowly turn up the voltage control until the meter reads to a stop. Note both the voltage and current at this point. This is called the voltage-current saturation point. Now, increase the voltage and note that the current does not change. (The system is now in current-regulation mode.) Rotate the voltage control back to the point where the voltage gives alarm to decrease. Then rotate the current control toward maximum and note that the voltage does not change. (The system is now in voltage-regulation mode.) If all these checks work properly, the supply is ready for use.

If you want to limit the current flow in an external circuit, short B1 and B3 and set the current control to the desired level. Remove the short and connect the supply to the circuit. No matter what happens to the circuit, the maximum current flow will be limited. As the voltage is brought up to the required value, the circuit current can be read off the meter. The supply can also be used for constant-current by presetting the current and varying the voltage.
adjusting your TV set for best color

Procedure used to get like-new picture

BY DAVID J. WATERS

A NEW color TV receiver, once properly set up, is capable of producing sharp, clear color pictures because the three beams from the electron guns strike the centers of their respective color dots on the picture tube screen. Light coming from each dot under these conditions is a pure color, uncontaminated by the other two colors.

As the months go by, however, things begin to happen to the sharp, pure color. Tubes begin to age and other components like capacitors and resistors begin to drift off-value. The aging and drifting worsens as time goes by. Fortunately, all color TV receivers are designed to permit adjustments that will satisfactorily compensate for component deterioration and other causes of color imperfection. In this article, we will discuss how to make some basic adjustments.

Purity Test and Adjustment. One of the major causes of loss of color clarity is a loss of purity. To test for color purity, tune your receiver for the best possible color picture, working with the fine tuning, tint (if any), tint, color, brightness, and contrast. Tune through all channels, looking for areas of color "blatches" common to all channel settings. If you note any such areas, color purity must be re-established.

Degaussing is the procedure used for restoring color purity. The only tool needed is a degaussing coil with a 10'-12' line-end and a momentary-action power switch.

Plug the coil's end into an ac receptacle so that your extension cord right up to the front of the picture tube and also back away 8' or 10' directly in front of the tube. With the TV receiver turned off, hold the degaussing coil parallel to the center of the picture tube and begin making small circular movements with the coil. While the coil is in motion, activate and hold the power switch and continue to describe ever widening circles until you have covered the entire screen area of the picture tube. Then, still depressing the power switch, back away from the receiver about 8' or 10' and let go the switch.

A word of caution: A degaussing coil develops a powerful electromagnet field that can destroy the speaker or the convergence magnets, as well as ruin a non-magnetic watch. So, do not bring a degaussing coil near the speaker or the rest of the receiver, and remove your wristwatch.

After you have completed degaussing the picture tube, tune on the receiver and tune in a color broadcast. Carefully recheck all areas of the picture for color imperfections. If any such areas still exist, degauss the picture tube again.
While you are examining the picture, take careful note of how the colors are converged. Do this with the color control set to a "natural" level—not too saturation. If the colors are improperly converged, the outlines of figures against a background of contrasting color will reveal color "fringing." The fringe may be red, green, or blue and, if present, indicates that re-convergence is necessary. Note, however, that some mis-convergence is normal for all dot-matrix picture tubes. Especially in close-up, and extreme top, bottom, and sides. So, if, at a normal viewing distance, the color fringing cannot be noticed, there is no need to re-converge the beams.

A note of warning is in order before proceeding. Unless you are familiar with the procedures to follow when working around high voltages, do NOT perform the following steps—have a TV technician do them. Once the back is off of a powered receiver, dangerously high voltages are present at various locations, so, if you do not know what you are doing, don't gamble on getting a bad shock.

Regardless of the need for convergence, purity adjustments must be made. Turn off the power from the receiver and remove its back. Turn the color control fully counter-clockwise. Then plug an electric cord to the receiver's safety interlock and the other end into an ac outlet. Turn on the power and allow the receiver to warm up until a full raster appears on the screen. Prop a mirror up at a convenient distance and angle in front of the TV screen so that you can readily see the screen image while working behind the receiver.

Bring careful to touch nothing else. Go to the back of the receiver and set the blue screen, and green screen controls fully counter-clockwise and the static drive, and green drive controls to "Lockwise.

Referring to Fig. 1, loosen but do not remove the three wing-nuts located on the yoke assembly at the back of the picture tube. Grasping two of these nuts, turn the yoke backward (toward you) until a red "flash" of color appears approximately in the center of the screen. You may have to advance the red sweep control. Center the flash in the center of the tube on the blue lateral assembly. Then slide the yoke forward (away from you) until the red area just fills the screen and tighten the wing-nuts.

Set the NORMAL/SERVICE switch to service and the rear fuse switch to the lowest setting that will permit the following two steps to be performed. Adjust the red sweep control until a low-intensity red line appears horizontally across the face of the tube. Back off on the control until the line just disappears. Repeat these two steps with the same screen; and green screen controls. Then set the NORMAL/SERVICE switch to normal, and alternately adjust the drive controls for neutral gray shades in the black and white picture on the screen. Note that the white areas appear at your viewing distance to be white and not reddish, greenish, or bluish.

**Color Convergence.** Having determined that your receiver requires convergence, place a color bar/dot generator atop the receiver cabinet (or any convenient location if this is not practical), plug it into an ac outlet, and connect its rf output cable to
The receiver’s antenna terminals after they receiving the local signal. Be sure the receiver tuned to the channel within the generator’s range. See the generator’s pattern control in use at cross-referent and tune the channel control for a sharp, flat-topped display on the face of the picture tube.

Set the pattern control for color tests and adjust the camera and color controls on the receiver so that the fourth bar from the left is reddish-purple and the third bar is red. A green bar should appear at the extreme right on the screen. Switch to normal.

Locate the three static convergence controls on the face of the picture tube and adjust them so that the red, green, and blue dots are in white dots in the center of the screen. Note that the blue control moves the blue dots up and down and the red and green controls move their respective dots, generally in opposite direction. If the red and green dots converge and the blue dots are at the proper height, but to the left or right, move the blue dots horizontally by operating the blue lateral control.

The dynamic adjustments are a bit more complicated to make since they involve each set in proportion to control of only one quadrant of the picture tube’s screen. Locate the convergence board and note the 12 controls with which you will be working, matching their positions with the layout drawing in Fig. 2. The three controls on the right are slant-ruled sets for which you will need the appropriate tool for tuning.

The dynamic adjustment procedure is accomplished manually through trial and error. Converging the dots at the bottom of the screen causes the convergence at the top to deteriorate and vice versa. Accordingly, a little adjustment in a tube that you have never used before may produce satisfactory results. In most cases, a compromise in convergence at the extremities will have to be made in order to keep the convergence in the all-important center of the screen as near to perfect as possible. You may also find that, in maintaining perfect center convergence, you have to go back to the static color adjustments for touchup. Note, however, that perfect convergence will be obtained in only about 1/3 of the entire area of the picture screen. It will be progressively worse at the four extreme corners and central center. This need not be an inconvenience, however, since, at normal viewing distance, the small error will appear to be slight, if not nonexistent.

**Editor’s Note:** The instructions for adjusting for color given here are general in nature. Not all sets have the same adjustments or require the same procedure. If you can obtain the service data for your particular set, follow the instructions given there.
AN EASY WAY TO DETERMINE

Reflex Enclosure Dimensions

BY E. G. LESCAULT

DESIGNING your own reflex speaker enclosure is really very simple (see "Rally Round the Reflex." PE. Nov., 1961) if you don’t have to juggle numbers. The monograph on this page lets you determine the optimum enclosure dimensions without much effort for a given enclosure volume in cubic feet. The scale calibration marks are set up to provide direct readings of length, width, and depth in inches for a given volume, all the while preserving the optimum 0.9:1:2:3:9 dimension ratio.

In use the monograph simply by setting edge down so that it intersects the appropriate cubic foot figure in the Volume column and the other three columns for the most convenient dimensions. For example, the line drawn across the monograph indicates a length of 35", width of 25-1/4" and depth of 15-1/2", each 7 cu. ft. enclosure volume.
Here is a unique device that masks disturbing noises by substituting the gentle "rushing" sound of pink noise. Self-contained, the pink noise generator can be assembled in less than an hour. Its masking effect should not be underrated.

Every fan of spy movies knows that the best way to keep hidden codes from picking up top-secret information is to repeat the information only while you've got a shower running. Why? Because the sound of the shower covers up the conversation. Probably any sound, such as jazzy hideouts in rock and roll music, would do, but a real spy will settle only for a shower because it simulates a thing called pink noise.

Pink noise is a special case of a large general class of signal called white noise. Whereas white noise is a random probability distribution of all possible frequencies, pink noise is a distribution which is weighted toward the high spectrum. Besides being able to mask outside sounds, white noise has some other interesting properties. For instance, many people find a rain-storm soothing, and white noise effects, such as the high concentration of sound in a rain storm, may contribute, at least part of the general feeling of well-being that we are frequently familiar with in the natural environment.

A type of pink noise is the same sound of the sound of the shower.

Some years ago a group of scientists experimented with the use of pink noise in...
Fig. 1. Operated in avalanche, Q1 serves as pink noise source. To preserve constant-level signal characteristics, C2 shoots appropriate levels of high frequencies away from earphone.

Fig. 2. PC board etching and drilling guide at top is shown full size. Directly above is component placement and orientation diagram.

PARTS LIST

- C1, 0.01 uF disc capacitor
- C2, 100 pF disc capacitor
- R, 150 KΩ carbon composition
- R1, 10 KΩ carbon composition
- R2, 100 KΩ carbon, 10% tolerance, 10% tolerance
- R3, 10 KΩ carbon, 10% tolerance, 10% tolerance
- R4, 10 KΩ carbon, 10% tolerance, 10% tolerance
- R5, 10 KΩ carbon, 10% tolerance, 10% tolerance
- B1, 9VDC battery

Note: The following parts are available from
- PFAA Electronics, Inc., PO Box 8930, Oxnard, California 93035

Theory of Circuit Design. As can be seen from the schematic diagram of Fig. 1, the circuit of the Chatter Jammer is very simple. Transistor Q1 is a silicon type that has a low emitter-to-base breakdown voltage rating. The base-emitter junction is reverse biased by the two series-connected 9 volt batteries that make up B1. In this setup, the base-emitter junction is operated in an avalanche condition.

Resistor R1 at the base circuit of Q1 limits the current flow through the junction and also serves as the load resistor for the shunt noise which results from the avalanche process. The random ac voltage fluctuations produced by the avalanche effect are coupled into a single common-emitter amplifier stage, Q2 through capacitor C1. Once the signal is amplified, it is coupled through C3 to the crystal earphone where it can be heard as a "whistling" sound similar to the sound you would hear if you held a seashell to your ear.

Capacitor C2 shields some of the high-frequency signal amplitude away from the earphone. As a result, all sound frequencies reaching the earphone are at one signal voltage level, giving the sound its "pink" characteristic.

Construction. There are only a dozen parts that make up the circuit of the Chatter Jammer, including the earphones and
battery pack. Add to this the fact that there are no high frequencies involved that could cause assembly problems, and you can readily see that just about any method of construction can be used. A printed circuit board, however, makes the project more compact and rugged. So, if you make your own circuit board, use the etching and drilling guide and components placement diagram of Fig. 2.

During construction, there is one point that you should be aware of. There is the remote possibility that the first transistor you try for Q7 might not be a good noise-sourced. Some transistors may not work at all, while others may produce a very "grainy" sound. About 95 percent of all 2N2512 transistors will give the proper results, so, if you buy two for the project, at least one and probably both will work fine.

A power switch is not used on the Chatter Jammer for a very good reason. The current drain of the project's circuit is to the inverter's output region which means you will obtain essentially shelf life from the batteries even if the project is left on all times.

Since the life of most 6 volt transistor batteries is so long, there is no reason why you should not simply wire leads from the batteries into the circuit instead of using battery clips that add to the project's cost. If you use this wise, the power leads, the leads can also support the circuit board.

The whole circuit, including board and batteries, is small enough to fit in a 2" x 2½ x 3½ plastic or Bakelite box (two photo). First drill a small pilot hole for the earphone leads in one end of the box. Pass the leads of two crystal earphones through the hole and tie a knot about 2" from the free ends of the leads. solder the leads to the appropriate points on the circuit board. (Note: Two earphones are used with the Chatter Jammer to increase the project's effectiveness. The addition of the second earphone will not affect the Life of the battery supply.) A thin piece of Styrofoam can be cut to fit inside the case to keep the battery pack from working loose.

How To Use. Once the Chatter Jammer is operating properly, the only operation involved is to plug the earphones into your ears. You should immediately hear a rushing sound. Don't be surprised if it takes a minute or so to get used to the sound and feel of the earphones. After a short time, you will not be conscious of the rushing sound, nor will you be disturbed by extraneous sounds.

Musicians can try using the Chatter Jammer as a noise source by breaking the ear phones off and connecting the output of the project to an audio high impedance input on their instrument amplifiers. For a really strange effect, try plugging the pick up through a variable gain amplifiers.

After you have used the Chatter Jammer for a while, you will be realizing to others in varying degrees of concentration or relaxation. It's sort of like having your own soothing rain sounds wherever and whenever you want to edge.
DESIGN YOUR OWN VOLTAGE REGULATOR

PUT A ZENER DIODE TO WORK

BY KEITH SCHOETTEPELZ

MOST electronics experimenters have a single power supply that is usually used for all types of projects. The only problem is that the voltage may not be correct for every possible application.

Now, with just a resistor and a zener diode, coupled with a minimum of pencil work, you can make a fixed voltage source that is also well regulated. Of course, the power supply must be capable of delivering slightly more voltage than the expected regulated output level.

Simple Circuit. The circuit to be used is shown in the schematic. Essentially, it consists of a resistor and a zener diode feeding the output load. The zener diode is a semiconductor device that attempts to maintain a constant voltage (Vz) across itself and it accomplishes this by drawing the proper amount of current to maintain the voltage. The maximum current through the zener is determined by the power rating (Pz) of the diode and is calculated from:

\[ I_{z\max} = \frac{P_z}{V_z} \]

The 0.9 factor is included as a safety measure to avoid overheating.

Essential circuit is resistor and zener diode.

The resistor limits the current flow. The voltage drop across the resistor is equal to the difference between the input voltage and the output voltage at Vz. If Vz (the output voltage) is to be constant, and Vn (input voltage) is constant, then the voltage drop across the resistor must be kept constant. This will occur only if Izn is constant or

\[ I_{z\max} = I_{z\min} \]

Thus, the function of the zener diode is to control Izn so that Izn remains constant under all load conditions.

The zener will function properly as long as the variation in load current is less than 90% of Izn. When the load current is maximum, the zener current will be minimum and vice versa. It is a good practice to assume a minimum load current of zero if there is any chance that the load will be removed entirely. If this precaution is not taken, the zener diode may be destroyed.

The component values for the zener circuit are determined as follows:

1. Choose a zener diode having the desired voltage.
2. Determine the zener power rating from
   \[ P_z = V_z I_{z\min} - I_{z\min}^2 \times 1.25 \]
   The 1.25 protects the zener against overheating and assures a minimum zener current that will be more than 10% of the maximum current. This is necessary for proper operation.
3. Maximum zener current is determined from the formula given above.
4. The value for the resistor is determined for the case when zener current is maximum and load current is minimum or
   \[ R = \frac{V_n - V_{z\max}}{I_{z\max}} \]
5. The maximum voltage of the resistor is calculated from
   \[ R_{z\max} = \frac{V_n - V_{z\min}}{I_{z\min}} \]

A typical example is shown worked out in the drawing. Other values can be "plugged in" to achieve various ratings.
LOW-COST CONVERGENCE GENERATOR

Produces a clear pattern, dots, crosshatch, or vertical and horizontal lines, using RTI logic.

BY MICHAEL S. CHING

CONVERGENCE is the sequential process by which the TV technician makes your color TV picture look like new again. It's actually a relatively simple set of checks and adjustments that are first made when the set is built and, of course, whenever the picture tube is replaced. However, component aging and mechanical shocks, particularly in locations, won't in a gradual one of the original adjustments. The changes often take place so slowly that many people don't notice the symptoms—color splatters, color fading, etc.—until unusual brightness, black and white, etc.

These problems can be easily detected and possibly corrected when you use the convergence generator described here. (Note that the generator is intended primarily as an aid in keeping the purity and convergence adjusted in an otherwise normally operating set. It is not meant to replace more complex color test equipment required to test a malfunctioning set.) The generator is used simply by connecting it to the set's antenna terminals. The required adjustments can be made without removing the chassis from the cabinet.

How It Works. The generator consists of two UJT oscillators and four comparators that provide constant feedback to the circuit checking for proper convergence. The output voltage is approximately 10V (OCA and 76.5) (OCL 2) produces horizontal convergence from 6 to 9
Fig. 1. This is the logic flow diagram of the convergence generator. The boxes in dashed lines show the four major sections: at left, the sync oscillators; upper right, horizontal drive; below that, the vertical drive; and, lower right, the r-f section. Some typical waveshapes are also shown to indicate circuit operation.
Six AA cells, wired to provide three volts, were used in the prototype.

microseconds wide at a pulse repetition frequency of 13,750 kHz. Capacitor C1 charges through resistors R1 and R20. When the voltage across C1 reaches the peak point voltage of the UJT (about 2.1 volts), the UJT makes a rapid transition into the negative resistance region, resulting in the discharge of C1 through the emitter-B2 junction. The positive pulse appearing at base now is coupled to the IC dual NOR gate one-shot for shaping into a pseudo-horizontal sync pulse. The output of a NOR gate is high (about 2.9 V) only if both inputs are low (less than 0.1 V). For all other input conditions, the output is low (less than 0.3 V). When two NOR gates are connected as shown in Fig. 2, gate IC1A is biased off (output low) and gate IC1B is biased on (output high). A positive pulse from the UJT causes the output of IC1B to switch to the low state, pulling terminal 15 of IC1A down through capacitor C3. With both inputs of IC1A now low, its output is high. The one-shot remains in this state until C3 has charged to above 0.1 V (6 to 9 microseconds), at which time the one-shot returns to its original state. This sequence is repeated for each triggering spike from the UJT, 13,750 times per second.

The vertical sync oscillator is similar to the horizontal except that the output pulses are about 0.5 millisecond wide with a pulse repetition frequency of 60 Hz.

The video sector consists of horizontal and vertical stable multivibrators, RC differentiators, and logic gates. The horizontal stable (IC2A and R28 in Fig. 3) is

synchronized to the horizontal frequency through C77, R3, and C22. Its output is thus fixed at an odd integral multiple of the horizontal line frequency of 13,750 kHz. Potentiometer R5 and resistor R32 set the output frequency by controlling the charging current to C14. For the component values shown in Fig. 3, the nominal frequency is

Fig 2. Horizontal and vertical oscillators feed one-shot multivibrators.
Fig. 3. Horizontal astable output determines width of vertical lines.

112 kHz (two cycles between horizontal sync pulses). The 112 kHz rectangular pulses are differentiated by C5 and R33. The resulting spikes are clipped and inverted by IC2. The width of the output spikes from IC20 determines the width of the vertical lines on the TV screen.

A second inverter for the dot pattern is performed by IC2D.

The vertical astable (Fig. 1) is similar except that it is tuned to twice the frequency (560 Hz) of the vertical oscillator. The rectangular, 560 Hz pulse train is differentiated by C5 and R26 before shaping and inversion to IC3E. The width of the pulse from IC3E determines the width of the horizontal lines on the TV screen.

Generation of the actual video waveforms associated with each of the five display modes is accomplished by sections of S1 and S2 and gates IC7C and IC7D. The video output waveforms are then combined with the sync pulses at the common-emitter junction of IC5 and IC6 (Fig. 4).

The sync pulses are added to the video waveforms to produce a composite waveform with negative-going sync pulses and positive-going video spikes. Diodes D1 and D2 comprise a pulse gate to ensure that either horizontal or vertical sync pulses are transmitted. With C5 saturated, the collector of Q3 is at a potential of about 0.7 V. In the absence of either horizontal or vertical sync pulses, Q3 is cut off and the collectors of Q5 and Q4 are at a voltage determined by the setting of RT. This Q3 is biased in its linear region.

When the video logic signal is high, Q4 is biased to provide approximately 15 V at its collector. When the logic signal is low, Q5 is cut off and its collector remains at 50 V. In the resulting composite video waveform, when applied to the appropriate stage in the receiver's video amplifier section, the generator test pattern would appear on the screen. However, to provide the need to make internal connections to work out the generator contains an inverter section.

The inverter section consists of an oscillator and a diode modulator (Fig. 5). Oscillator Q5 is operated in the tapped-Heiltey configuration. The frequency is achieved by C36 and terminated by C35. The inverter is created by C37 to the diode modulator.

With a high signal (3 volts) applied through B4, the output terminal has a low impedance to ground through 011 forward biased) and C22 and a high impedance to the +4 oscillator due to diode D3 (which is reverse biased).

When the modulating waveform goes low (less than 0.5 volts), diode D4 is cut off and diode D3 conducts, this allows the flow of radio-frequency current from the oscillator to the output terminal. The negative modulation convention used in American TV broadcasting translates an increase in the output amplitude into a decrease in brightness of the trace. In this way, the complex modulating signal is converted into a black and white pattern on the TV screen.

Construction. A printed circuit board was used.
Fig. 4. A 540-Hz oscillator driven by vertical determines horizontal line width.

Fig. 5. Output of r-f oscillator and dual-diode modulator circuit drives the TV set.
wire. Use a 2-1/4-in. round bobbin, with bare end being the other. Then carefully unwind the coil until the ends are 4-in. apart. Bend the end leads to the proper angle and remove the resistor before mounting the coil. Before the coil is soldered to the board, add a bare lead at G18 to the coil, then turn from the end connector to the collector of Q3. Note that this lead at G18 does not go through the board, but directly to the coil.

The stationary plates of C26 are connected to the collector of Q3, and the moving plates to the ground bus on the board. These two plates are marked "CAP" in Fig. 6. Capacitor C25 is soldered directly across C30.

**Operation.** Before turning on the generator, check the battery polarity and voltage. There should be 3.0 V between the positive side of the battery and ground on the board. To check the completed generator, connect it to either a black-and-white or color TV set. (Because of the very low plate power output and the blocking capacitance C32, the generator cannot damage the
TV set, even if the generator is not properly adjusted.

Before getting into the operation of the generator, let's summarize the front panel controls and their functions. First, there is the vhf switch (M1). Besides turning the power on and off, it is used to select one of five displays: clear white screen (M8), dot array (MT), crosshatch (M10), horizontal lines (M9), and vertical lines (M1). The dot switch varies the r-f carrier frequency over the range of these five channels (18 MHz). The monochrome switch varies the frequency of the horizontal sync oscillator about a nominal 18.750 KHz. The vhf control varies the frequency of the generator's vertical sync oscillator about a nominal 60 Hz. When adjusting either the vhf or vhf control, you may find more than one setting which results in a sym. of the pattern. Use the setting that results in the most stable display.

Make the following preliminary potentiometer adjustments:
1. Set R7 about 8 up from the grounded end. This potentiometer sets the black level of the composite TV signal.
2. Set R4 fully counterclockwise.
3. Set R2 fully clockwise.
4. Set R5 and R6 to midrange.
5. Disconnect the vhf switch from the set and attach the generator to the vacuum tubes of the set.
6. Tune on the TV set and plug in either channel 2 or 3, whichever is needed in your area. Turn the generator power switch on.
7. With the plates of C20 (green, control), fully meshed, adjust trimmer C25 until the output signal from the generator appears on the screen with little or no buzzing from the set. This should be a clear noise, a completely white screen. Whether it is or not, continue to the next step.
8. Tune the stone switch to the YL position. Adjust the r-f control to stop any vertical motion of the test pattern. Adjust the monochrome control to eliminate any diagonal lines or "fisheating" on the pattern. You should now have horizontal lines.
9. Touch up the adjustment of the vhf switch to eliminate any noise and to provide the clearest display. You may now begin to increase the TV's brightness control and increase the contrast to get white horizontal lines on a black background.
10. Trimers R3 and R6 are used to set the stability and number of horizontal lines, respectively, though there will be some interaction between them. Adjust them for 9 or 10 horizontal lines and the best stability. Use the vhf and monochrome switches to maintain vertical and horizontal sync as necessary.
11. Turn the stone switch to the VI position. If vertical lines do not appear, touch up the monochrome switch.
12. Trimers R3 and R5 are used to set the stability and number of vertical lines. Adjust them for 9 or 10 vertical lines and the best stability.
13. Turning the stone switch to the EU position should now produce a 9 by 9 or 10 by 10 crosshatch pattern. Touch up the adjustment of the cross, smoke, and vhf controls as necessary. Trimmer R7 may be reset slightly to provide the best balance between sync stability and pattern contrast.
14. Turning the stone switch to the neutral or neutral should produce a 9 by 9 (or 10 by 10) array of dots on a clear meter, respectively. Always turn the stone switch off when not using the generator.

Once the potentiometers on the board and C25 have been set, the cabinet can be closed. Mark the positions of the monochrome switch and vhf for future use.
You don't have to be a mathematical genius to design a simple solid-state amplifier. All you have to do is follow some basic rules, cut and try a little, test the circuit, and there it is! The mathematics involved in complete top-level circuit design may require the knowledge of a graduate engineer, but unless the circuit is critical, there are some shortcuts that can be used by the serious electronics experimenter. These shortcuts yield "ballpark" figures that work well with components having ±10% tolerances.

To explain what we mean by shortcuts and simplicity, we will use as an example the design of a microphone preamplifier. In this design, math is at the high school level and Ohio's levy is the most complicated formula involved. All the designer has to do is "plug in" the numbers necessary for his particular application.

Preamplifier Design. Suppose you want a microphone preamplifier that will reach a low-impedance dynamic mike to a much higher power amplifier with an input impedance of 5000 ohms. In other words, you want to make the dynamic mike "look" like a crystal mike. Note, however, that the procedure described here could be used for matching an input device of any impedance to any circuit impedance simply by changing the necessary figures and using the appropriate transistors.

The design is accomplished in eight easy steps:

1. Write down all the pertinent facts about the circuit (see Fig. 1). It was determined by tests that the output of a crystal mike could not handle a maximum of 0.3 volt (amplified) and that of a crystal phonograph pick-up.

2. Write down basic circuit facts.

3. Design the circuit.

4. NPN

   $h_{fet} = 120 \text{ AT}, 150 \text{ MA}.$
   $i_{c} = 40 \text{ VOLTS}$
   $i_{e} = 40 \text{ MHz}$
   $O_{c} + F = 85 \text{ MHz}, 25^\circ$
   $0.5 \text{ M} \Omega \text{(COMMON EMMITTER)}$

   Fig. 2. Consider transistor characteristics.
Figure 3. These are circuit parameters.

Figure 4. Two circuit configurations.

Fig. 5. Draw basic circuit diagram.

Note that single-battery bias is used. This bias method provides better results as far as temperature stability and other factors are concerned. Also, contrary to some beliefs, this is the easiest system to design.

- 4. Now we can draw a preliminary design, such as that shown in Fig. 5. The battery supply is included, capacitors are marked for polarity, and components are numbered for reference.
transistor. Thus, the voltage at the base of the emitter follower should be four volts when there is no input signal. To achieve this drop across R2, R1 has to be 7500 ohms.

For the common emitter stage, R7 is a noncritical value in most cases and can be "picked out of the air." If the wrong value is chosen, we will find out later in the design. A good value to choose for R7 is 10,000 ohms.

In this stage, as before, R5 is 10 times R7 or 100,000 ohms.

The value for R9, which must be chosen before R4 can be determined, will be approximately equal to the output impedance of the amplifier. The modulator or power amplifier input is a voltage amplifier because of the high impedance. Since the output of the preamplifier is required to be a voltage generator, the output impedance can be much less than the input impedance of the modulator or power amplifier. The stage need not transfer maximum power, only maximum volts, so the impedances need not match. Eventually, the entire output voltage from the common-emitter stage will be felt at the input of the amplifier if its output impedance is less than about 1/10 of the input impedance of the amplifier. In fact, 1/100 would be a better figure, so R6 is chosen to be 10,000 ohms. Normally, at this time, R8 would be considered in regard to the desired voltage gain. A quick check shows that the 10,000-ohm value provides a gain of over 20.

To make sure that the output of the amplifier is class A (and none Q2 is a current amplifier,) the bias through R6 is chosen to be half of its maximum value. The maximum current through R6 will be about 0.75 milliamp in the transistor, or about 0.36 milliamp in the class A bias point.

Resistor R4 is selected to provide the 0.36-milliamp bias current. There should be about 0.20 volt across R7 with this current flowing. Since this is a small voltage, we may take into account the 0.8-volt drop at the base-emitter junction of the transistor. Thus, the voltage at the base of the transistor must be 0.8 + 0.36 = 1.16. Therefore, R4 is chosen to provide 1.16 volts across R4. This turns out to be about 68,000 ohms.

- 6. To calculate the values, replace the circuit, showing all bypassed resistors as shown, by the input impedance of the following stage as resistors (Fig. 6). Note that R2 and R2 in parallel form Rs, which is in parallel with Z, of the emitter follower to form the amplifier input impedance. Since the input impedance of the emitter follower is dependent on the input impedance of the common emitter, we must determine the latter from Fig. 4d. Since R = 0.89 milliamp and beta is 59, the input impedance is 3600 ohms. The latter is in parallel with R4 and R5, the bias resistors. The parallel value of R4 and R5 is approximately 8800 ohms, while a parallel with 3600, comes to about 2560 ohms.

The 2560 ohms is paralleled by the emitter follower's own Rs to the emitter sees about 500 ohms. The emitter follower input impedance becomes 500 times the beta or 25,000 ohms.

**Fig. 6. Determine the resistor values.**

**COMMON COLLECTOR.**

- R1
- R2 = 3000 ohms
- R3 = 10,000 ohms
- R4 = 10 ohms
- R5 = 1000 ohms
- R6 = 100,000 ohms

**COMMON EMITTER.**

- R1
- R2 = 3000 ohms
- R3 = 10,000 ohms
- R4 = 10 ohms
- R5 = 1000 ohms
- R6 = 100,000 ohms

**Fig. 7. Convert to equivalent ac design.**
The input impedance of the entire amplifier is $R_3$ (3600 Ohms) in parallel with 25,000 or 30,000 ohms, which is what is desired. If the values were found to yield an overall input impedance which was not 3000 ohms, the components would have to be adjusted appropriately.

The voltage gain of the amplifier depends on the gain of the common emitter stage, which, from Fig. 4A, is about 140. Thus the amplifier meets the gain requirement of at least 50.

Capacitor values are chosen so that the response at 100 Hz is 3 dB. So, we have the impedances associated with a particular capacitor and solve for an equivalent $X_C$. Since the input impedance is 3000 ohms, $X_C = 3k$ ohms. (See Table IV.) Keep in mind that, if you cannot hit this value, a larger capacitor will only lower the response and probably won't be ideal.

Bypass capacitor $C_4$ is associated with a 1000-ohm resistor and its value will be close to 2 pF. Capacitor $C_3$ and the 10,000 ohm input impedance combine for a value of 0.2 pF, and the reactance of $C_2$ must be 500 ohms so its value is about 6.3 pF.

Insert all of the above figures into the circuit as shown in Fig. 8.

Fig. 8. This is the final circuit layout.

- 7. Recalculate the circuit. When recalculating reactor values, keep the same ratio between the values and increase or decrease until you come close to something you have. For instance, assume the first have a 7500 or 8000-ohm reactor for $R_1$ or $R_2$. You know the values can go up, so find the ratio of $R_1$ or $R_2$-which is 1.25. An increase in both values will merely raise the input impedance, which is not objectionable. Thus, as shown in Fig. 8, $R_1$ and $R_2$ were changed to 13k and 17k respectively, since they were readily available.

Fig. 9. Testing input/output impedances.

If you want to change the value of $R_3$, you will have to go higher, since lowering its value would lower the 3000-ohm input impedance. Keep in mind that, if in some applications, the impedance may not be allowed to be different from that calculated.

Now we can build the circuit. Apply power and check the voltage levels in the emitter of both transistors. This tells us whether the bias values are correct. It also tells us whether or not the circuit will operate. Then we correct it to the other devices (circuit and power amplifiers) to see if the whole thing works.

- 8. You may not wish to perform this last step, but if you have an audio generator, use the hook-up shown in Fig. 9 to measure the important parameters of the circuit. Figure 9A is used to measure input impedance. Adjust $R_1$ until the voltage at the input is half its maximum value. (The value of $R_1$ should be greater than the estimated input impedance of the amplifier.) Then remove $R_1$ and measure its value to end resistance.

This value will be approximately the same as the input impedance of the amplifier.

The output impedance is measured in the same way by adjusting $R_2$ in Fig. 9B. The voltage gain is found by using the circuit in Fig. 9C and dividing the output by the input. Frequency response is found by adjusting the frequency until two points are obtained at which the output is 0.707 times the maximum. These are the upper and lower 3-dB power-loss points.

Now the design is complete. The checks should show no values that need adjusting. Parts can now be purchased, printed circuit boards can be etched, etc., etc.
Switching Logic Quiz

BY ROBERT P. BALIN

Switching circuits do only what they are logically designed to do. Understanding this logic is very important in designing electronic circuits. In the switching circuits below, the lamp symbols may represent lamps, or some other device or mechanism. Switches which simply apply and remove power to a practical circuit are not shown. Match the statements (1-10) to the circuits (A-J).

1. Scientists must be in complete agreement before they can fire a missile.
2. A code is used to indicate whether the front, rear, or both doors are open.
3. When the darkness light is on, the warning light switches is off, and vice versa.
4. Either one or both of the operators can set the motor.
5. Since the pilot might get excited and push the wrong button, they are wired so that, regardless of which is pushed first, the canopy is blown off, and the second button fires from the plane.
6. Only the fastest gun can hit the target.
7. The decision will be made by a simple majority of the voters.
8. You can turn on the light before you climb the stairs and extinguish it from the top.
9. Let me know if an odd number of those present want to go ahead.
10. We want an indicator lamp to light when the amplifier is set.

(Answers on page 96)
What Makes the TRANSISTOR Tick?

UNDERSTAND TRANSISTORS WITHOUT MATH

BY ROBERT B. WOOD

THE TRANSISTOR, be without a doubt, the most important component known to modern electronics technology. It can be found, in discrete form or as one of many transistors in integrated circuits, in every electronic device that employs, or modern technology. The sophistication of electronic computer, communications and telemetry systems, electronic diagnostic equipment in medicine, and many consumer items can be traced directly to the transistor.

But as complicated in use as the transistor appears to be, understanding its physical makeup and how it operates is quite simple. What brightens most beginners to the study of solid-state devices is the high technical and mathematical level most tutorials works employ in explaining the devices. Many times, a better understanding of transistor theory can be obtained from a non-mathematical treatment—a device employed in the following pages.

Germanium and silicon are the basic crystal materials from which all transistors are made. Because they have most of the properties of metals, which conduct electricity from one point to another in the equivalent, but under ordinary circumstances are non-conductive in the manner of insulators, germanium and silicon are borderline substances. They are, consequently, neither conductors nor insulators, but something in between.

In nature, an atom containing four electrons in its innermost energy level is in a stable, or electrically inert, structure. Seven electrons are the primary current carriers in the conduction of electricity; it is easy to see that any atom with a full outer electron ring is by definition an insulator, incapable of giving up an electron to serve in the current carrying process.

In their pure states, germanium (Ge) and silicon (Si) exist in an electrically inert and inert state in the manner of an insulator. However, Ge and Si can be transformed into current carriers simply by adding minute amounts of impurities to the pure crystalline substance through a process known as doping. The addition of impurities does not by any means transform Ge and Si into good conductors in the manner of metals such as iron and copper. Instead, the doped crystals behave like a poor conductor, conducting only small
amounts of current. Hence, they have come to be termed semiconductors.

To understand why a semiconductor does not perform in the traditional manner of a conductor, it is best to compare it to copper, the second-best conductor available. Each copper atom has only one electron in its outer ring. This electron is loosely bound to the nucleus of the atom and, under electrical influence, is relatively free to wander as a conductor of current. In Ge, on the other hand, due to the privileged electron of the impurity, there may be only one so-called "free" electron per million atoms.

Now, when a copper conductor is subjected to electrical influence, electrons or ions are free to circulate. This is not true when a doped Ge or Si crystal is subjected to electrical influence. Although the free electrons do circulate, there are not charge separations of flux since they are very few and far between.

The type of impurity added to the pure Ge and Si crystal determines whether the semiconductor will be n- or p-type. Although the following analysis will focus attention on Ge, it should be understood that the discussion applies equally well to Si.

To make n-type Ge, which has electrons as the principal current carriers, a small amount of arsenic or phosphorus (injection into even elements currently in use) is added throughout the crystal. Each of these impurities has four electrons in its outermost electron ring. Now, if only four electrons are required for a stable electron configuration, arsenic or phosphorus have one extra electron apiece left over for current-carrying purposes.

The p-type Ge, on the other hand, has impurities such as boron, aluminum, or indium added. In the uncharged state, each of the impurity's elements has only three electrons in its outermost ring. So, to attain stability, it must "borrow" an electron from a neighboring Ge atom.

Once the Ge atom gives up an electron, it has one more proton in the nucleus than there are electrons in the electron rings. Hence, it becomes a positive charge known as a "hole." The word "hole" derives from the fact that there is a vacancy in the Ge atom into which electrons can fall.

From our discussion thus far, it is easy to see that in p-type Ge, holes are the principal current carriers. (Although in reality it is the electron that carries the current, the hole appears to do the moving.) In the n-type Ge, electrons are the principal current carriers.

The simplest semiconductor device, the diode, can be represented by the diagram in Fig. 1. The diode consists of a sandwich of n- and p-type material. Where the two types of material touch, we have a junction which is responsible for providing both transistors and diode action.

The hole carriers, which are circled plus signs, predominately in the p-type material. The electron carriers, which are represented by minus signs, predominately in the n-type material. Note that in both types of material, the current carriers are in a permanent minority.

With no voltage applied to the diode, no voltage difference exists between the two types of material and the current carriers are pin. Now, connect a battery across the diode as shown in Fig. 2, and observe what happens.

The positive pole of the battery repels the holes and attracts the electrons in the p-type material. Likewise, the negative pole of the battery repels the electrons and attracts the holes. The repelled charges move toward the junction where more of the holes and electrons combine and become neutral Ge atoms. For every atom thus "neutralized,"
an atom in the p-type material loses an electron to the positive pole of the battery and thus begins its migration toward the junction.

With the battery connected to the diode as shown, the semiconductor is forward biased. In this condition, the continuous hole replacement and drift toward the junction process makes up the current flow. The process will continue until the battery is disconnected or it runs down.

As mentioned earlier, holes are only apparent current carriers. It is the electron that still carries the current through the semiconductor material to provide current flow. During the interchange, an atom of Ge leaves its place in the crystal.

To simplify the process of hole movement, let us make an analogy to a supermarket checkout station. In Fig. 3, we see four customers at the checkout counter. One customer has already checked and vacated the position in front of the cashier, thus creating a hole. The next customer moves up to the counter, in turn, creating a hole behind him, and so on down the line until all four customers have moved up one position. The checkout counter remains where it is, just as the Ge atom remains put in the semiconductor. Only the customers have moved, just as only the electrons in the semiconductor move. The vacated space made by each customer as he moves up only appears to have moved, just as the holes in the semiconductor appear to move.

With the hole movement problem cleared up, let us reverse the polarity of the battery to obtain the setup shown in Fig. 4. Here, the holes attracted by the negative pole of the battery move away from the junction in the p-type material, and the electrons attracted by the positive pole of the battery move away from the junction in the n-type material. No current flows, and the semiconductor is said to be back or reverse biased, allowing a minute amount of current to flow in the reverse direction. If an alternating voltage were applied to the junction instead of dc, the current would flow each time the junction is forward biased and cease when the junction is reverse biased.

In a vacuum tube rectifier, half of the cycle is usually and clearly eliminated because of the large distance between the anode and cathode of the tube—compared with the contact made between the n and p parts of a semiconductor diode. In the latter, the minute reverse current flow resulting from the undetected carriers does not allow complete rectification. A small portion of the unrectified half cycle gets through, but it does not hamper effective rectification and, in most cases, can be disregarded.

The transistor can be viewed as two diodes connected back to back as illustrated at the upper left in Fig. 5. Each diode consists of a block of np-type and a block of p-type material (shaded drawing at top of Fig. 5). In the transistor, the center block is shared by each of the outer blocks in turn to make up the diodes.

There are two basic types of transistor. One is an npn with a block of p-type material sandwiched between two blocks of n-type material, the other is a pnp, with
signal in the form of a voltage must first be converted to a current by passing it through base resistor \( RB \). Once converted to a current and applied to the base, it allows current to flow across the base-emitter junction. The current traversing the junction is limited by the value of \( RB \) and the level of the potential supplied by input drive battery \( B_1 \). As long as current circulates through the base-emitter junction, there will be current flow through both junctions.

The collector current, resulting from the flow of majority carriers from the emitter through the base, is many times larger and directly proportional to the base current that initiates it, because the base region is narrow, most of the carriers moving through the emitter and into the base are propelled into the collector. In practical transistors, 90-99 percent of the carriers from the emitter reach the collector. Hence, almost all of the current from the emitter flows through the collector (the order of hundreds of milliamperes), while it is controlled by a very small base current (usually on the order of only tens or hundreds of microamperes). That’s amplification.

The amount of current that flows through the collector is controlled by the degree to which the base is biased by \( B_1 \) (our base drive signal), the collector potential supplied by \( BE \), and the load resistor \( RL \). If we change the value of \( RL \) and the voltage of \( B_2 \) and substitute a variable-voltage input signal for \( B_1 \), we can easily vary the output from zero to maximum. Hence, it is possible to use the amplifier for audio and r-f purposes.

The output signal from the amplifier is in the form of a voltage. As the current passes through the transistor and \( RL \), it causes a voltage drop across each. The voltage drop across the transistor, from emitter to collector, is the output signal. It is necessary for \( RL \) to be in the circuit so that a voltage drop can be developed across the transistor.

Fig. 5. Three methods of drawing transistors.

Two blocks of p-type material separated by a block of n-type material. Schematic symbols for each type are shown at the bottom of Fig. 5. Note that in the schematic representations the arrow on the emitter always points toward the n-type material (direction of hole flow)—toward the base in the pnp transistor and away from the base, or the emitter itself, in the npn transistor.

The center block in the transistor is known as the base, while the outer two blocks are the emitter and collector. In the practical transistor, the base is much thinner than are the emitter and collector blocks. This is done to aid in the amplifying ability of the transistor.

In Fig. 6, we see both types of transistors connected in amplifier configurations. In both cases, the base-emitter junction is forward biased in the direction of easy current flow, while the base-collector junction is reverse biased to oppose the free flow of current. Hence, the emitter and collector are said to be connected series aiding, with control of the majority carriers from the former to the latter directly dependent on the base drive.

Bear in mind that the transistor is a current amplifier. This means that a base drive signal in the form of a voltage must first be converted to a current by passing it through base resistor \( RB \). Once converted to a current and applied to the base, it allows current to flow across the base-emitter junction. The current traversing the junction is limited by the value of \( RB \) and the level of the potential supplied by input drive battery \( B_1 \). As long as current circulates through the base-emitter junction, there will be current flow through both junctions.

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Fig. 6. Basic arrangement for npn transistor is same as for pnp, except battery polarities.
A Practical Expanded Scale Milliohmometer

MEASURING THE ALMOST UNMEASURABLE

This test instrument was developed to measure what most electronic experimenters are inclined to think of as inconsequential resistances. However, the less-than-1-ohm losses are important factors in detecting hi-fi ground loops, poor contacts in high amperage circuits, corrosion, etc. The circuit is a simple, easily balanced bridge. Provision is made in the instrument for long storage and battery protection.

CONVENTIONAL home and field-type VOMs are not designed to resolve accurately resistance readings between zero and one ohm. Even the very best multimeters employ a logarithmic scale, with 10 times as many decades in the scale reading when the range switch is in the high-ohm position. And you need a very sharp eye indeed to differentiate between readings of 100-0.65 and 0.05-ohm on a counting transformer.

Commercially available photolithography

BY DAVID R. CORBIN
are expensive instruments, costing $125 and more. However, with modern solid-state equipment in which biasing resistors in the 0.1-ohm range are common, a milliohmeter is almost a unit for measuring such values. By combining unmeasurability ranges and maintaining an accuracy to within practical limits, it is possible to build a milliohmeter for less than $50.

The milliohmeter described in this article has two very useful ranges—0.1 ohm and 0.01 ohm. The zero is very near linear. It would take very expensive and elaborate equipment to show that it is not, but in actually a very precise of a bimetallic curve, expanded to cover the full swing of the meter pointer.

Theory of Circuit Design. As shown in Fig. 1, the circuit of the milliohmeter consists of a resistive bridge, one side of which is made up of the test leads (lead resistances being measured). Closing S1, permits current to flow from R1 via R2 to the bridge.

With S2 in position 2 and the test leads shorted together, R3 is adjusted to balance the lead resistance, balancing the E-B ratio of the R2-R3 side of the bridge. The meter will now indicate zero, regardless of the setting of R1. If the test leads are disconnected, with S7 closed, the bridge will be heavily unbalanced in a direction such that current will flow from R6 through the meter to R1, swinging the meter pointer off-scale.

For calibration purposes, S2 is set to 0 for the 0.1-ohm range or position 3 for the 0.01-ohm range. If S2 is in position 4, R7 is placed in series with test leads, unbalancing the bridge circuit and moving the meter pointer by an amount determined by the value of R7. Potentiometer R2 is then adjusted to produce a full-scale deflection.

Setting S2 to position 5 and placing a 0.1-ohm resistor across the leads will also cause a full-scale deflection of the meter pointer (assuming that the setting of R2 remains unchanged). Hence, it is possible to compare the standard external resistance of R6 and R7 with the values of resistance being measured and obtain direct readings in terms.

Resistor R5 is used to smooth the operation of R1 and also balance the bridge. An optional feature of the circuit is R8 which provides a useful internal resistance for checking calibrators.

Construction. Assembling the milliohmeter should present no problems, since there is nothing critical about the circuit. As shown in Fig. 2, all components, except the battery bank and its holder, mount directly to the front panel. To simplify...
Fig. 2: The simplicity of the circuit allows all components to connect directly to the control and meter lugs.

The battery supply for the circuit is mounted in place with the aid of three AA cell holders and machine hardware.

Recalling a hard service cement bonding is used between the top of the housing of switch S1 and front panel and between the battery holder back and case. The reset movement, binding posts, filament switch (S2), and photoelements fasten in place with the hardware supplied.

Since there are only a few components, wiring by the point-to-point method is easy. Note, however, that the leads of three batteries that make up M2 must be connected in parallel with each other. More often, mounting the binding posts make electricity contact both are isolated from the front panel. Once the circuit is wired up as illustrated in Fig. 2, assemble the case. Now, make your test leads. Flexible type leads are useful for the radiometer. When not needed by the two ends of the cables are strong spring-loaded clips that will lock solidly onto the leads of the components under test. This is necessary because in dealing with resistance measurements the fraction of an ohm range, current resistance becomes an important factor in accurate calibrations and test readings.
It is not necessary to use any special type of test lead cable, nor are the lengths of the cables critical. The instrument is designed so that in zero-adjusting and full-scale-deflection calibration, the test lead becomes part of the bridge circuit and are "nullled out," regardless of their specific resistances. It may seem strange that you have to consider test lead resistance, but the meter will clearly demonstrate that if a null is obtained in one lead only, the meter will indicate half-scale deflection with both leads—and after calibration will give the resistance in milliohms of the lead not used in the nulling procedure.

How To Use: First, short together the alligator clips on the test leads. It is best to clip the leads together in the same manner as they would be clipped in the leads of the component under test. This will assure good contact resistance. If you merely hold the clips together with one hand, you will find adjustments difficult to make because of the varying pressure you exert on the clips. Especially noticeable on the 0-10-kilo range will be the "lumpy" movement of the meter pointer.

Next, set R1 to maximum resistance and set R6 to the zero circuit position, Depression SB and adjacent null control BS brings zero meter reading. Then release SB and set SB to the desired range position. Again, depression SB, adjusting the setting of null control BS for full-scale pointer deflection.

Release SB, set SB to the zero circuit position. The meter is now ready to measure resistance values in the range for which it was calibrated.

When using the null-calibrator, set SB to the same position. The meter will show the absence of damage for off-scale readings. It should be noted that the meter should be recalibrated if it is recalibrated if the full-scale reading changes. A similar procedure is followed for ohmmeters and other similar meters.

When checking the accuracy of test leads, it is desirable to have available for calibration a range of 10 resistors with at least a few milliohms of resistance is used. Other tests include interchanging resistors, capacitance, and other similar tests as described in the manual. The instrument can be used to check resistance in automobile wiring connections, a range of 10 resistors with at least a few milliohms of resistance is used. Other tests include interchanging resistors, capacitance, and other similar tests as described in the manual.
BUILD THE
X\(\times 10/\times 100\)
INSTRUMENT SENSITIVITY BOOSTER
EXTEND THE RANGE OF YOUR SCOPE OR VTVM

BY JAMES BONGIORNO

MOST low- and medium-priced oscilloscopes have input sensitivities between 10 and 15 millivolts per scale division. This means that, if you are probing for very low-level signals (such as 100 to 200 microvolts of noise in a preamp), even a wide-open gain control on the scope may not help.

Of course, you can always build a preamplifier which simply boosts the scope's input sensitivity, but you may run into more problems than you solve. The bandwidth of an amplifier for this purpose must be at least as good as that of the scope. The amplifier should not introduce any noise of its own, it must not clip the signal, and it should have good rise and fall times, very low harmonic distortion, and a high enough input impedance to avoid loading the circuit under test. Obtaining these qualifications in a better preamplifier is not impossible. What you need is the X10 X100 Instrument Sensitivity Booster.

The specifications in the Table show just how good the Booster is and a glance at the circuit in Fig. 1 will prove that this is not just an everyday preamp but a carefully designed, highly useful instrument "add on."

The Booster can also be used to extend the range of old VTVM's that do not have the very low voltage scales required for semiconductor voltage measurements.

Construction. It is best to build the Booster on a printed circuit board, using the full pattern and component layout shown in Fig. 2. Since the board is small and spacing is close, take care not to make
Fig. 1. Besides being an instrument preamplifier, either or both stages can be used wherever a high input impedance, low-noise broadband amplifier is required.

**PARTS LIST**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C6, C5, C12</td>
<td>100 μF, 450 V electrolytic capacitor</td>
</tr>
<tr>
<td>C4, C16, C17</td>
<td>450 μF, 25 V electrolytic capacitor</td>
</tr>
<tr>
<td>D2</td>
<td>1N4119 diode</td>
</tr>
<tr>
<td>F1</td>
<td>50 mA, fast-acting instrument fuse</td>
</tr>
<tr>
<td>Q1, Q3</td>
<td>Field-effect transistors (Motorola E191)</td>
</tr>
<tr>
<td>R1—R23</td>
<td>330 kΩ, 1% metal film or carbon</td>
</tr>
<tr>
<td>R24</td>
<td>1 kΩ, 1%, carbon</td>
</tr>
</tbody>
</table>

**Note:**
- B1—Two 7 volt mercury batteries in series (Silver, TR-133 or similar)
- BP1, BP2—Dualing resistors (100K ohm ± 5% or similar)
- C1—0.01 μF, 450 V paper capacitor
- C2—0.05 μF, 600 V paper capacitor
- C3—450 μF, 500 V electrolytic capacitor
- C9, C10, C11—0.001 μF, 500 V electrolytic capacitor
- C25, C26, C27—566 μF, 50 V electrolytic capacitor

**Resistors:**
- R1—R23—330 kΩ, 1% metal film or carbon
- R24—1 kΩ, 1%, carbon

**Miscellaneous:**
- H1V—310 volt rectifier, 5% tolerance
- R1, R5—100,000 ohm, 5% carbon
- R3, R16—100,000 ohm, 5% carbon
- R7—2000 ohm, 5% carbon
- R8, R18—500 kΩ, 5% carbon
- R9, R24—120 kΩ, 5% carbon
- R10—47000 ohm, 5% carbon
- R11—2200 ohm, 5% carbon
- R12—2200 ohm, 5% carbon
- N1, N2—Input glide switch
- H2—Battery holder, aluminum chassis (duo RE-3013A, or similar), mounting terminal strip, mounting hardware, power cord, etc.
solder bridges between adjacent foil lines. Also note that, if you duplicate the prototype shown here, R4 and R15 are mounted on the full side of the board. They can be mounted on the component side if you prefer another mechanical arrangement.

A 1\" × 2\" × 2\" aluminum two-piece chassis can be used to hold the PC board plus the batteries, switch, and input/output meters. As shown in the photographs, the battery clips are mounted on the bottom of the U-shaped chassis with 2-inch PC board mounting screws between the clips and 45° apart. The dual binding posts, one for the input and the other for the output, and the two switches are mounted on one long side.

After mounting the two PC board mounting screws, place a nut on the screw nearest the input jacks and about 1\" above the chassis bottom. Place a one-hole terminal strip (ungrounded) on the screw, and secure it in place with a lockwasher and nut. With the batteries in place in their clips, place C1 in position on top of the batteries and solder one end to the "hot" input connection (BF1) and the other end to the mounting terminal strip along with the end each of R3 and R2. The other end of R2 is soldered to the general battery clip connector along with the negative end of C13. The other end of R1 is connected, through line C1, to the input terminal of the PC board.

Before permanently securing the board in place, temporarily mount capacitor C9.
The circuit board is mounted on a pair
of long screws using nuts and washers to
keep the board in place. The batteries
mount in clips secured to the base of
the chassis. Note that in the original
prototype, both potentiometers are
located on the under (foil) side of board.

and resistor R25 to ground. Connect the
battery power, and wait a few seconds for
the voltage to stabilize. Connect a de
voltmeter between test point A and ground
(see Fig. 11) and adjust R4 until the meter
indicates exactly 7.5 volts. Do the same at
test point B using R15 to make the voltage
adjustment. Remove the two temporary
shorts.

Wire the complete circuit as shown in
Fig. 1. Then mount the PC board on the
two long screws, using a nut, below and
above the board to secure it in place. All
grounds should be made to the same
grounded battery clip where the negative
end of C75 is connected.

Although 7% resistors are specified for
the gain-determining elements (R10; R17.

The off-board components forming the input to the circuit are supported by a
terminal strip affixed to a supporting screw. Use one point as common ground.

TERMINAL

CIRCUIT

GROUND

ELECTRONICS EXPERIMENTER'S HANDBOOK
R21, and R22), they may be trimmed if desired to obtain more exact multiplication ratios. Do not substitute for Q1 and Q3 as this particular FET has exactly the characteristics required for best operation of the circuit.

Operation. Since the overall noise at the input is less than 7 microvolts, the Bowler can be used to trace very low level signals, and it can be used at frequencies up to 10 MHz. If you use a scope having an input capacitance of less than 10 pF, measurements to 10.7 MHz (FM range) may be obtained by using a suitable probe. Sensitivity is high enough in the X100 range to view a signal as low as 70 microvolts with a 20-dB noise margin.

Since the rise time is fast (50 nanoseconds or less), the Bowler can be used with all types of electronic systems. However, remember that it is an undifferentiated preamplifier and should be used with a high-input-impedance scope.

HOW IT WORKS

The Bowler contains two similar stages of amplification, each having a gain of 15 (29 dB). Two stages were used to get the high gain as well as extend the frequency response. If only one stage were used, there would be less feedback and the frequency range would be to only 700 kHz rather than 7 MHz.

The inputs to both stages are FET's having a high input impedance and are connected in the bootstrap mode to further increase the input impedance. The FET's also have a lower noise level than a bipolar transistor, especially when the source impedance is high. The actual frequency response is determined by the two bipolar transistors in the input.

Resistor R1, base resistor R2, dc bias, C1, and C19 form the dc input protection circuit. Any positive input voltage that exceeds the 15-volt battery level causes Q1 and Q2 to be forward biased. As the voltage increases so does the voltage drop across R1 therefore also increases. Capacitor C15 provides this dc current to ground to protect the battery. When the current reaches about 200 mA (depending on the amount of reverse bias and the time constant), the fuse blows.

On the negative excursions, any voltage more negative than about 2 volts forward biases Q3 and Q4, clamping the signal to ground. Capacitors C6 and C5 bootstrap the protection diodes at high frequencies so that their capacitance does not short the input impedance.

TECHNICAL SPECIFICATIONS

Gain: X10 or X100, optional switching
Frequency response: 2 MHz to 7 MHz (1-3 dB)
Maximum output level (before clipping): 3.5 volts rms
Input impedance: 1 megohm in parallel with less than 10 pf
Equivalent wideband input noise: less than 7 microvolts, input shorted
Rise time (unloaded): 50 nanoseconds or less
Fall time (unloaded): 50 nanoseconds or less
Harmonic distortion up to 20 kHz (X10 position):
less than 0.05% at 8 volts rms output
less than 0.15% at 1 volt rms output
less than 0.35% at 0.5 volt rms output
Maximum dc input: 500 volts
Maximum input level: total dc and peak ac should not exceed 600 volts.

The connections to the input and output of the preamplifier must be made carefully to avoid degradation of the signal. The best method is to use short pieces of wire to make all connections to the scope. Do not use coaxial cables as the preamp will not drive coax properly at high frequencies.

DC input protection is provided by C7 which should have a rating of 600 volts dc or more. Remember, however, that the total input voltage should not exceed 600 volts—the dc level plus the peak ac signal.

"So why should the experimenter have to start from scratch when we can give it to him in kit form?"
Build a RECHARGEABLE FLASHLIGHT

CONVERT YOUR BATTERY-EATING FLASHLIGHT TO A MODERN RECHARGEABLE

NOW that you can get low-cost, rechargeable nickel-cadmium batteries (1.25 volts), why not take advantage of them and build a flashlight that can be recharged from either the 117-volt ac power line or a 12-volt vehicle supply? The rechargeable circuit shown here provides either fast, slow (overnight), or trickle charge.

Provided B is made for two power inputs: H for ac and J2 for dc. In ac charging, connector F1 is connected to J1. In this case, because the dc plug P2 is not connected to J2, Transformer T1 and rectifier diodes D1 and D2 provide a dc source of 3 volts. A jumper in P2 connects the common return line. The charging current applied to the cells is determined by how much of M1 is in the circuit. When S2 is in position C, it is a few milliamperes flow, providing a trickle charge. In position B, the resistance of F2 is cut to permit the circuit manufacturer's specified overnight charging current to flow, while position A connects the cells directly to 3 volts. The current flow in the last case is a few hundred milliamperes (must be measured when the circuit is built) and can be used to operate the flashlight from an ac source. The current must not exceed the cell rating. A brass H11 fixture holder and fuse in the ac line is suggested.

In dc charging, the 12-volt supply is applied to J2 through J1. In this case, the two cells are connected between the ends of H1 and a slide so that 4 volts is present across the cells. Switch S2 must be in position C for dc charging.

There are two approaches that can be taken in construction. One is to build the entire flashlight in a small enclosed chassis with a flashlight head (lamp and reflector) on one end and J1 and J2 installed and identified on the side of the enclosure.

The second approach is to cut a small two-contact jack on an existing flashlight case that will hold the nickel-cadmium cells (instead of the D cells normally used) and connect the two jack terminals to the cells by soldering. Make sure that this jack is keyed so that its associated plug can be installed in only one way. The nickel-cadmium cells can be damaged by application of reverse polarity. The rest of the components can then be installed in a small enclosure with a cable connected to the flashlight when recharging.

The only component requiring selection and adjustment is R1. This resistor can be between 75 and 100 ohms and should be rated at least 10 watts. One slider should be at the 99% point and is connected to position B to S2. The other slider should be set at the point where 3 volts is applied to the cells when the dc connector is in place and 12 volts is applied to the circuit.

Using the manufacturer's specifications, select a value for R2 that will allow a trickle charge to pass through the cell when S2 is in position C and the charger is on ac. The dc power supply cable can be fabricated from a 12-volt automotive inspection light cable with a 4-pin connector.

PARTS LIST

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1, S2</td>
<td>125-volt rechargeable and de-cadmium cells (Eveready CT, N561, Procter C5DL; Fairchild 46.866, or any equivalent that will charge from the available voltage)</td>
</tr>
<tr>
<td>J1, J2</td>
<td>12-volt rectifier diode</td>
</tr>
<tr>
<td>M1</td>
<td>450-mw flashlight bulb (PR-3)</td>
</tr>
<tr>
<td>L1, L2</td>
<td>1/2-watt choker coil series</td>
</tr>
<tr>
<td>F1, F2</td>
<td>12-volt connector plug</td>
</tr>
<tr>
<td>N1</td>
<td>100-ohm, 10-watt potentiometer variable with two slider contacts</td>
</tr>
<tr>
<td>Q1</td>
<td>Slide switch (RJ-112)</td>
</tr>
<tr>
<td>P1, P2</td>
<td>Single-pole, three-position switch</td>
</tr>
<tr>
<td>R1</td>
<td>1-3/4-ohm 1/2-watt resistor</td>
</tr>
</tbody>
</table>

ELECTRONIC EXPERIMENTER'S HANDBOOK
1. Digital technology comes to TV with the new Heathkit GP-2000 ColorTV—an advanced set like nothing you've seen before! It has on-screen tuning, full-color rectangles, and optional digital clock. A programmable digital counter silently selects channels. Up to 16. No blank channels. Intermix any UHF and VHF even blank channels if you wish. The long-life all-electronic automatic color correction circuit eliminates noisy mechanical switches and protruding contacts. The unique new fixed-inter-tube amplifier never needs realignment—so color pictures remain brilliant and steady year after year. Its new 1025-a-sled-base chassis has more integrated circuits than any other TV. In new HP (diagonal) marks picture tube is the most advanced available. The Heathkit GP-2000 Digital Color TV may be the best reward for all your years of life. Kit GP-2000, $699.95*, less control.

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CIRCLE NO. 3 ON READER SERVICE CARD

1973 Winter Edition
Build an

ALPHA BRAIN WAVE FEEDBACK MONITOR

You may be able to learn how to relax through electronics

BY MITCHELL WAITE

There is nothing quite so pleasant as being able to relax completely whenever you want to. Unfortunately, today's quick pace rarely leaves us the time to truly relax.

Perhaps for that reason, scientists have come up with an electronic approach to relaxation that might revolutionize the art of "turning down." Drawing on knowledge of general psychology, eastern meditation techniques, and, in particular, electroencephalography, researchers in the field of alpha-wave feedback have proved rapidly in the last few years and made many significant gains.

Unlike the older forms of meditation, alpha-wave feedback requires neither an order nor a room. Researchers have found that the intense brain-wave frequency band between 8.5 and 13 Hz is continuously produced in meditative stages of Yoga and Zen. This is called the "alpha state." The assumption is that the length and intensity of alpha-wave production is an impartial measurement of the ability to reach a special state of "relaxed awareness." Used in certain types of meditation.

People who produce continuous alpha seem to experience a generally heightened sense of well-being, with a parallel increase in clarity. Thus, alpha feedback allows one to prepare for demanding mental tasks by precisely clearing the mind of distracting thoughts and ideas. It is precisely for this reason that some businesses are investigating alpha feedback. Researchers are also suggesting that the "pain" of education can be turned if these procedures are used in attention control. There is the possibility, they say, that every class can be improved, and mental blocks avoided during examinations, by the use of alpha feedback.

Basic Approach. In alpha feedback, high-gain, low-noise amplifiers detect the microvolt signals of the brain and use them to modulate a sound or other stimulus. The person training for increased alpha completes the feedback loop by listening to the cue and half of a tone as the brain waves come and go. Thus, by learning to produce just the elusive 7.5- to 13-Hz modulation, a person can experience the alpha state.

Actually, all brain waves have elec...
Electrodes, which couple the microvolt signals to the amplifier, are critical in two respects. They should not generate short-term voltages (e.g., noise spikes) or long-term voltages (offset or drift). A number of low-cost commercial machines use inert material, such as titanium steel for electrodes. The difficulty with these electrodes is that they produce some noise spikes and (more seriously) generate a slow voltage offset, which (if the montage is direct coupled) can eventually saturate the output. A better approach is found in laboratory applications, where silver electrodes coated with a layer of chloride are used. Though these electrodes are free of noise and have no long-term voltage drifts, the chloride surface must eventually be replaced as the electrodes become disposable types. However, with proper cleaning, they will last for some time. The least trouble-free approach is to use pellet-type Ag/AgCl electrodes which, due to their special construction, last indefinitely.

Another more general consideration in designing an EEG montage is the type of modulator used to produce the audio feedback. Most models use the amplification-filtered basic wave either to modulate or frequency-modulate a fixed tone. In the circuit described here, a unique combination of both methods can be employed to produce either AM, FM, or a combination of the two.

It is also necessary to determine what aspects of the brain wave envelope shall alter the tone. The two most common methods use either a direct or integrated waveform to modulate the audio. With the mode selector switch, S1 in the system position, the instantaneous waveform passing through the filter frequency modulates an adjustable tone. The mode creates an effect in which one seems to be hearing directly to the source of the brain. If the continuous tone is objectionable, the oscillation can be set just below the threshold point so that only the peaks of the filtered waveform trigger the tone. The latter method integrates the filtered waveform over a fixed period of time.

In this monitor, depending on the setting of the threshold control (C142), the tone can be made absent when no signal is present. When the threshold is exceeded, the frequency of the tone is proportional to the envelope of the signal. This mode is better for biofeedback training since the
Fig. 1. Brain waves are amplified and used to drive the multivibrator that provides acoustic output to the ear.

PARTS LIST

<table>
<thead>
<tr>
<th>PART</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2, R3</td>
<td>4.7K ohm, 1/4 watt, 5% tolerance</td>
</tr>
<tr>
<td>R4, R5</td>
<td>330 ohm, 1/4 watt, 5% tolerance</td>
</tr>
<tr>
<td>R6, R7</td>
<td>1K ohm, 1/4 watt, 5% tolerance</td>
</tr>
<tr>
<td>R8</td>
<td>220K ohm, 1/4 watt, 5% tolerance</td>
</tr>
<tr>
<td>R9, R10, R11, R12, R13, R14</td>
<td>100K ohm, 1/4 watt, 5% tolerance</td>
</tr>
<tr>
<td>C1, C2, C3, C4</td>
<td>0.01F, 5% tolerance</td>
</tr>
<tr>
<td>C5</td>
<td>0.001F, 5% tolerance</td>
</tr>
<tr>
<td>C6</td>
<td>0.002F, 5% tolerance</td>
</tr>
<tr>
<td>C7</td>
<td>0.005F, 5% tolerance</td>
</tr>
</tbody>
</table>

RL, R20, R21, R22, R23 | 470 ohm, 1/4 watt, 5% tolerance |

This circuit consists of a microphone input, amplifiers, and a multivibrator to produce the acoustic output.
Fig. 2. Actual size foil pattern is at right with component layout above.

Fig. 2. Actual size foil pattern is at right with component layout above.

A tone gives a direct indication of the desired result.

This monaural unit has an audio amplifier with speaker and volume control (R43), so that a group can listen or the volume can be reduced to a quiet level.

**How It Works.** Integrated circuit IC1 and IC2 amplify the differential signal between the two input leads while providing unity gain for the common mode signal. The residual common mode signal is removed by IC3 and can be balanced to zero by trimmer R49. The signal is then coupled through C1 to IC4 and further amplified. The gain of this stage can be varied from about 5 to 100 by the setting of R42.

Integrated circuit IC3 forms a two-pole

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active filter which rejects signals lower than the frequency determined by capacitors C3 and C4 and R11 through R16. Conversely, IC6 removes signals higher than its selected frequency. The net effect is a filter which passes only a narrow band of low frequencies.

With Q7 as a short switch and C9 and R28 as a smoothing filter, the signal is passed to Q7, a FET operating as a source follower with unity gain. Integrated circuit IC7 is connected in a multivibrator circuit and is initially saturated with the output voltage near the positive supply voltage. When C9 charges through R36 to a voltage higher than the level provided by the voltage divider made up of R30, R33, R32, and R34, IC7 saturates due to positive feedback. Capacitor C9 then discharges through R2 until IC7 flips back to its previous state. The signal from Q7 varies the charge on C9 and thus modulates the tone.

Transistor Q2 is a source follower which provides a low impedance to drive the speaker without overloading the multivibrator. A separate battery (B7) is used for the speaker to avoid feedback.

Transistor Q3 is a source follower which creates a low-impedance ground about half way between the positive and negative supply voltages. This also permits the use of a single-side switch (S3) to turn the monitor on and off. It is not necessary to disconnect R1 because its drain is negligible with S3 open.

**Construction.** The use of a PC board (foil pattern shown in Fig. 2) makes construction easy. Mount the components as shown, observing the notch and dot code of the ICs. Also make sure that the two diodes and three transistors are properly installed. The lettered terminals correspond to Case 3 of the schematic. The resistors associated with S7 are connected directly to the terminals on the switch. Use fine solder and a low-power soldering iron.

The circuit board and batteries can be installed in an small enclosure. The three potentiometers (R11, R12, and R13) and the two switches (S7 and S8) should be mounted on the front panel, with a small ground lug hole also on the front panel for the shielded cable. The speaker is connected to the front panel with a few holes drilled in the panel for the wires to come through.

Prepare the electrode cable by removing about 1/2" of the outer insulation from the cable. Unwind the thread and twist it into cable form. Solder the leads to the end-tip. Run about 1/2" of insulation from the two insulated leads and carefully solder them to the electrodes. When soldering to the rainbow core, first lightly coat the metal surface with fine sandpaper.

**Testing.** Install fresh batteries, turn the circuit on, and adjust the tone threshold control (R12) until a tone is heard from the speaker. Set the bandpass switch (S4) to its lowest range (13.0-7.0 kHz) and the mode control (S2) to direct. Using a small amount of electrode cream, clip the ground lead to the cathode. Saturate the electrodes with cream, and steadily half one electrode in each hand. The circuit should pick up your breath, amplify it, and send it through the speaker. This is a noticeable beep, about once a second. The pulse signal is about 1 millivolt (10 times greater than alpha-wave level). So turn the gain control down. If you cannot hear your pulse, check the wiring.

If you have a signal generator and scope, the circuit may be further analyzed by clipping one input and the ground lead to the signal-generator ground, and feeding an attenuated signal into the other input lead.
The dc output of all op-amps should be zero.

Balancing the Amplifier. A capacitance of 0.01 uF is used to tune the gain of one side of the differential amplifier to make both gains exactly the same. When they are equal, common mode rejection ratio is maximized. The best procedure is to feed a common mode signal of 3 to 4 volts into both inputs tied together across a 15,000-ohm resistor. Put a scope on a VTVM on the output of R3 and adjust R20 for the smallest signal. If you do not have a scope or signal generator, hold the electrodes through the 15,000-ohm resistor to ground and touch the common lead. You will hear 50 Hz noise from your body. Adjust R19 for maximum noise of the cleansed tone.

Use of the Monitor. First, a note of caution. The monitor, like most commercial machines of this type, is battery operated. This is to prevent a shock in the case event that the 50-Hz power line shunts to the inputs. Therefore, for safety sake, avoid keeping the monitor in any air-conditioned equipment such as scopes, battery chargers, etc. When no devices are hooked up to the EKG monitor in a laboratory, light coupling devices or based Gibbon systems are used.

If you are not the monitor is picking up EKG and properly balanced, you are ready to try the EKG feedback. Place a small bit of electrode cream on the scalp and attach it to the electrodes. Wrap an elastic or soft cloth band around the head, aligned so that it is over the electrodes and at the occiput at the back of the head. Put the cloth to hold it in. Put a small amount of cream on each electrode and place one under the head just above the left or right eyebrow. Place the other in line with the first at the side of the head. Spread the base and add a little more cream. The electrodes will function best when they show above the scalp with electrode cream bridging the gap. With the electrodes placed in this manner, you should be picking up mainly what is called occipital alpha. In more advanced stages of meditation, alpha production increases in the frontal areas of the brain. You can experiment with this by placing both leads on the forehead.

Sit or lie down in a quiet, comfortable place. Turn the monitor on, place the head--pass switch in the alpha range. 17.8-13.8 Hz, with mode in off. Run the gain all the way down and adjust the tone and volume to a pleasing level. Blank your eyes and listen for a beep. Slowly turn the gain up. If all else fails, are correctly placed, no harm will be heard. Now, with the eyes open and focused on an object, adjust the gain for a lovely steady tone. Remember you are producing mostly beta and the bandwidth is on alpha you should not hear the beta frequencies. Now close the eyes and listen for a faster modulation of the tone. Try not to produce this fluttering let the natural graph and just listen for it. The occasional fluttering of the tone will be the alpha waves.

Notice the types of changes that block the alpha. Afterwards, are some you are producing alpha, switch SS to music-careful adjust the threshold tone control so that when the eyes are open, there is no tone. Shut the eyes and practice increasing the number of times the tone is on (percent tone training). Later the increasing the frequency of the tone (amplitude training).

In laboratories training a mental alpha session last 10 or 25 minutes a day for about two weeks. If you show it, you may eventually notice a feeling of well-being and motivation after each session. To experiment with the other brain-wave bands, simply repeat the procedure with the filter switched to the desired band. Try lowering the dominant alpha frequency toward theta, in the direct mode and notice if spontaneous thoughts or ideas came more easily.

When you have satisfied using the monitor, carefully wipe the cream off the electrodes. If you are using stainless steel electrodes, wash them lightly and clean them with alcohol.

One final note: alpha-wave feedback has produced results similar to meditation, but it works much faster. It is still, however, a subtle effect and requires diligence and experimentation to obtain worthwhile results.

Editor’s Note: This article describes an easily constructed project. For experimentation, there have been many claims made for brain-wave monitors—some highly exaggerated. We make no such claims, other than that the circuit operates properly.
Special Tools for the Electronics Workbench

What tools you need, where to get them, and how they are used.

Shown are (top left) Moody pin vise, X-acto drill set (top right) and pin vise with interchangeable collets (center), electric drill (bottom).

Tools play an important role in the progress of the electronics hobby. Having the right tool for the job not only makes things easier, but it also helps retain your interest and builds learning potential. But having the tool does not necessarily mean that the user knows how to use it. Nor does knowing that a specialized tool is needed mean that the builder will know where to start.

While this article is concerned primarily with having the right tool for a given job, some general advice in locating tools and how to use them is given to those tools of a special nature that are not ordinarily found on the electronics workbench but are very useful in performing certain special operations.

General Purpose Tools. Electric drills are used almost universally these days, and the drills are essential for making the hundreds of small holes in a PC and the thousands of tapping holes. The average drill set contains drills from No. 1 to No. 30 {1256"-14006" in diameter}. All well and good, but for the most part, what are needed are drill bits much smaller in diameter than these. The most suitable ones for PC and similar work lie in the range of No. 31 to No. 50.
Fig. 1. To properly use battery-powered drill, when working on printed circuit boards, hold it perpendicular to work surface and apply minimal force.

You may never have heard of such drills, but if you plan to do PC jobs, you will need them or at least enough of them to fill your needs.

Xacto Inc., manufactures an manufacturer of good hobby tools, make a set of five drills. They are contained in a neat little stand with drill size and diameter clearly labeled. The whole is topped by a clear plastic dome cover. You can buy Xacto drills from select dealers at Auto World Inc., 701 N. Kennedy Ave., Scranton, PA 18508; E & H Model Hobby Center, 169 W. Pattison Ave., Philadelphia, PA 19144; and many well stocked hobby department stores.

Individual drills, sizes 36 through 82, are available from America's Hobby Center, 110 West 22 St., New York, NY 10011 at 25c each plus shipping and handling. The size most frequently used for component work in PC comes in a No. 65 drill.

Do not make the mistake of using the very fine drills in an ordinary 115 volt hand drill. You will only break one drill after another if you attempt to do so. For hobbyist/special interest work, these drills are best used in a hand held collet, otherwise known as a pin vise, of a small battery-powered electric drill.

Shown on the opposite page are various drilling devices. The small pin vice—made by Mood—shown at the upper left are available from E & H Model Hobby Center, the larger one, shown center with three interchangeable collets, is made by Xacto Inc. The battery-powered electric drill, bottom is available from America's Hobby Center and from Auto World Inc. Some or all of these items might also be available locally from tool or hobby centers.

A pin vice is useful where only two or three holes have to be made in soft materials such as plastic or foil drilling holes in thin metal. For operations that require drilling many holes, the battery-operated drill is your best bet. Figure 2 shows the proper method of using the electric drill when working on PC boards. The two-handed operation allows precise positioning of the drill point and metal finish from one hole location to another. First, punch the center point of the hole, position the work about 15 in. below eye level, and make sure the area is well lighted before you begin. Also, when performing the actual drilling, make only enough pressure to cause the drill point to enter the work.

Batteries last a surprisingly long time in the drill. As you may want to use the drill for such diverse operations as delimiting and wire bonding, the supported on a PC board, before etching.

You cannot very well use an ax to sharpen a pencil. It is equally impractical to use an ordinary hack saw for working on miniature electronic assemblies. The saw shown at the left in Fig. 2 is undoubtedly the finest available for the equivalent of a 1/4" blade and no other saw can do what this one does. It is called a Zona" saw. It has very fine teeth and a blade thickness of only .0085"—extremely thin by any standards.

The Zona saw is made of Swedish steel, a material that is tough rather than brittle. It will cut through anything from plastic to solid brass with surprising ease and speed. The blade itself is unreplaceable.

There are three grades of Zona saws available. The No. 200 shown has 32 teeth per in. 24" long and makes a 7° bevel cut. The No. 300 in progress.
its blade has 24 teeth, is 0.017" thick, by 0.7" long, and cuts to a 2" depth. The No. 500 is a "tiny" saw; its blade has 32 teeth, is 0.010" thick by 0.5" long, and cuts to 1/4".

A Zona saw well handle perhaps 75 percent of all cutting chores in electronics.

Specialized Tools. Shown at the right in Fig. 2 is a particularly useful tool. In two, it is the only tool known to this author that will remove epoxy-encapsulated parts. With this tool, a minute component can be removed from a chassis or PC board to which it is mounted without damaging either component or its mounting. The tool, a hot knife, is a soldering-iron-like device that is fitted with a clean and stainless steel blade instead of a soldering tip.

The hot knife cuts thermoplastic, rubber, and insulation. The ease and neatness with which it works is truly amazing. Some of the jobs that can be performed with the hot knife are routing and shaping styrodur blocks; use for thermal isolation in temperature-controlled crystal oscillators; acoustic insulation cutting for some speakers; rubber and making clear plastic disk windows.

A couple of important points should be borne in mind when using the hot knife. First, make certain that the tool tip is up to temperature before attempting to make a cut. And, second, once one begins to cut, continue without hesitation until you are finished. If you stop, even for a second, you will produce a plastic blade that will ruin the appearance of the work. Always clean the knife blade of any adhering plastic before allowing it to cool.

Do not attempt to use an ordinary hobby knife blade in the hot knife. Ordinary blades cannot bear up to the high melting temperatures without deteriorating.

Hot knives are available from such suppliers as Arko World Inc. and America's H-Buy Center.

We have saved the best for last. Shown in Fig. 4 is the most unique, most versatile, and most useful all-applicable tool to be found on any workshop. Compared to other power tools, its most unique feature is that it is so easy to make special accessories to fit it. Not only that, but this tool, plus the battery-operated electric drill discussed earlier, can make 95 percent of the average items used in electronic equipment, from sockets—including the cabinet that you use to house your electronic projects.

**Diameters of Fine Drills**

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Fig. 2. Shown here left to right are Swedish steel Zona saw, replacement Zona saw blades, and hot knife tool.
Fig. 3. Vibrator tool and accessories provided with it are shown arrayed above a row of homemade accessories.

This amazing tool is a reciprocating vibrator of the type used by jewelers for engraving celebrity. But it is much more powerful than the usual variety, and its stroke is continuously adjustable from zero to a full 1/4. It has two operating speeds: 3000 and 6000 strokes per min. The slow speed is of special value to the electronics hobbyist and experimenter, as the high speed is used for engraving.

Shown immediately below the vibrator in Fig. 3 are the accessories that are supplied with the tool. Using these accessories, the vibrator tool will engrave, gauge, cut, carve, saw, and grind. The tool's chuck will also accept a large number of X-acto accessories.

The eleven accessories shown in the bottom row were home made, designed specifically for use in electronics work. The four chucks at the left end of the row are saws, made from lengths of ordinary hacksaw blade and contoured on a bench grinder. Their shank ends were shaped to fit the chuck of the vibrator, while the cutting ends were shaped to fit special job requirements.

The fifth accessory is also a saw, but this time it is fabricated from a section of a Zona saw blade. It is sharpened, re-ground, and soldered into a slot in the end of a 3/16-in. by 3/4-diameter soft-steel shank. The accessory shown was made from a 0.008-thick, 32-leaf-inch Zona blade.

The five accessories at the right end of the row are files intended primarily for working on metal parts; they are made from short or shortened Swiss needle files. The handles of each were cut off at the required length. Then the handle stubs were force-fit into holes drilled in soft-steel shanks of the same dimensions used for the Zona blade.

The most valuable feature of the vibrator tool is that accessories like the homemade files and saws can be accommodated quickly and easily. In a particular file or saw is needed for a special application, it can be fashioned in a matter of minutes.

The accessory in the center of the row is a winder. It consists of a 1/2" x 5/8" x 1/16" piece of mild-steel plate that was force-fitted and soldered into a slot cut across one end of a soft-steel shank. Normally, one side of the plate has a piece of medium-grit sandpaper cemented to it, while the other side has fine grit paper.

The way you use the vibrator tool is of considerable importance. Bear down lightly, and move the tool slowly back and forth, all the while you are making a cut. If you hold the tool stationary or bear down too hard, you are likely to get nowhere.

The vibrator tool discussed here and shown in Fig. 3 is available from Sears Roebuck & Co., 4646 Roosevelt Blvd., Philadelphia, PA 19132.

No attempt has been made in this article to discuss the everyday, common tools as screw and nut drivers, soldering iron and gun, etc. These tools are all readily available from hardware stores and electronics parts dealers. Furthermore, they are so familiar to the hobbyist and experimenter that they need neither introduction nor instructions on their uses. One point, however, is an underlying code of all tools: Use the correct tool at all times. Do not "substitute" one tool for another. Each tool was designed for a specific function; use it for that function and only that function.
MODEL rocketry is currently one of the fastest growing of hobbies. Unlike slot-car racing and other fads that have come and gone in the recent past, model rocketry promises the hobbyist the type of permanence that has continued to draw new adherents to airplane modeling for decades. And it holds the key to new areas for experimentation for the electronics enthusiast.

With today's micro-technology and lightweight components, quite a sophisticated electronic package can be put together to make up the useful payload (everything only a few ounces) of a typical model rocket. Entwining electronics, rocketry, hobbies, and hobbies are losing (as long for launching) live mice (fire) thousands of feet into the air and teleporting back to earth their temperatures, pulse rates, and breathing rates via tiny radio transmitters. Other experimenters are using similar transmitters to conduct meteorological (weather) studies, and still others are studying the performance of the rocket itself by means of simple accelerometers and sensors designed to monitor velocity and roll rate.

**Getting Started in Rocketry.** Model rocketry demands only a small cash outlay to get into the hobby. Simple kits for assembling a rocket, airs, engines, are available for less than $1, while rocket engines can be obtained for as little as 25 cents.

The beginner to model rocketry is advised to exercise his first effort to a kit-built rocket to learn what goes into the design and fabrication of a rocket. As he gains experience, he can graduate in designing and building his own creations, making use of sturdy paper tubes, balsa and plastic noses, and fins, and other accessories available from hobby shops. Most manufacturers of items for rocketry publish booklets and other literature detailing how to design rockets from scratch. Books on the subject often go into greater detail.

A typical home-made rocket consists of a 14-in. (or longer) paper tube that is 1 in. in diameter and is fitted with three fins. Black balsa stabilizes fins, and a commercial balsa nose cone. A plastic dry-cleaning bag and some cord are often used to make a parachute, while an engine restraining block can be made from a sawed-off section of used rocket engine. The total cost for the materials might average about 75 cents, depending on how much one can be made of make-do or salvage items.

![Parachute ejection.](image)

A simple launch stand made from a 36-in. length of wire piano wire, a metal flame deflector, and a base plate are used for launching model rockets. One or two holes cut from a plastic drinking straw and glued to the side of the rocket can be slipped over the piano wire to guide the rocket until its velocity is sufficient to provide aerodynamic stabilization from the air.

For safety and efficiency, the rocket engine is ignited electrically from a remote location. The igniter is usually made from a 2.5-in. strand of Nichrome wire coated with a flammable plastic. The wire is inserted into the engine's throat and held in place with tape or wadded tissue. The free ends of the igniting wire go to a pair of clip leads that trail off to a spring-loaded normally open switch and 6-volt automobile or lantern battery.

When switch contact is made, the Nichrome wire heats rapidly, igniting the plastic which, in turn, ignites the engine.
MODEL ROCKETRY for the Electronics Experimenter

An exciting hobby and an interesting application of electronics

BY FORREST MIMS

almost immediately. At lift off, the rocket takes only a few seconds to attain a velocity of several hundred miles per hour. The nozzle burns out quickly, and the rocket goes for miles at the height of its flight toward space. To maintain altitude, most engines have a slow-burning powder charge that produces a trail of white smoke. After the tracking charge is cut, a small engine/charge is shot off the nose cone and ejects the parachute that returns the rocket back to earth.

Most homemade rocket engines burn to 14,000 or more feet, but more advanced rocket engines that sometimes exceed 30,000 feet, can produce up to 1 pound (28.3 grams) of smoke. There are dozens of types of rocket engines, each with their own characteristics. Some engines are meant for small rockets, while others are for "muzzle" rockets. The most popular engines produce an average thrust of about 15 pounds for a burn time of 20 to 30 seconds. Engines are also available without the parachute-eject capability for use in multi-stage rockets.

The most powerful rocket engines available are made by Control Engineering Corporation, under the name Encraft. While these engines employ a low-tempereatrate propellant, the engines are available in high-temperature propellant (solid and liquid) versions. These engine configurations provide an average thrust of about 15 pounds for 3 seconds, enough to send a 5-pound rocket to an altitude of approximately 10,000 feet. Truly professional engines, the Encrafts have epoxy casings and reinforced graphite nosecones.

Enter Electronics. The launch of a "hobbyist" rocket provides little scientific data. The real fun comes when a rocket is equipped with instrumentation, telemetry, and propellant systems. Palen was one of the first and is currently the largest of the manufacturers of model rocket supplies and engines. Their Transo transmitters weigh only 1.5 ounces, including batteries, but it can be used in a wide variety of applications.

The Transmission system can be used to telemeter temperature and altitude data, as well as bearing signals from a coasting downed rocket. It can also be used with a crystal microphone to send back in earth sounds, the roar of the engine, the sound of the blast, the fuselage, the noise of the chutes' actions, and the sound of the chute forces against each other as the rocket falls. Other transmitters and modulators are available from AirComm Communications, Trim Comm Systems, and Microcraft Electronics.

Besides telemetry, a simple transmitter system can be built with a battery, a push to talk device, a "beep" system, and a "beep" system, to send text data, and a "beep" system. A "beep" system is only a few feet long and 10 inches in diameter, and can get lost easily during launch, especially on a windy day. The optimum recovery system enables launchers to make the rocket recoverable without the parachute-eject capability for use in multi-stage rockets.

Warning: Before launching rockets, always check your local authorities for maximum altitudes permitted in your area and any other safety conditions that may apply. Also, remember that a rocket engine is dangerous, and extensive care must be used when storing, transporting, setting up, and igniting.
of a radio frequency transmitter (in the rocket), a receiver, and a loop antenna.

Tracking is the basic application of the telemetry transmitter. Ball race, for example, can be measured by connecting a photocell to a transmitter so that variations in its resistance cause an audio tone to vary in frequency. The photocell is mounted in the payload section in a manner that permits light to enter from only one side so that each revolution results in the transmission of a complete tone cycle to a ground receiver at the cell alternately moves toward and away from the cell. A tape recorder can be used to record the signal for later study.

A slide-type potentiometer, with its wire attached to a spring or rubber band, and a small weight can be used to measure accelerations. As the rocket accelerates, the wiper contact slides back and changes the modulation of the transmitter. As the rocket slows down, the spring or rubber band returns the wiper to the neutral position. To calibrate the readout in a potentiometer, a number of small weights are hung from the wiper end. The spring tension is adjusted until each weight is balanced against the wiper end.

Velocity can also be measured if care is used in designing an appropriate antenna. One technique you might try is a pressure-sensitive device that consists of two thermistors. One thermistor is inside the rocket, the other outside. Another is a small propeller that spins backward for each revolution made. Velocity sensors are calibrated to home-made wind tunnels or are mounted on the outside of a car and monitored at a range of highway speeds for the results yielded. If acceleration is known with respect to time, velocity can be calculated and used to calibrate or check a velocity sensor.

Sensors can also be used to monitor the pulse and breathing rates of small payloads. For example, a photoelectric sensor that employs a photocell can be arranged so that...
it responds to variations in light intensity affected by the moving front of the breathing mouse. Light can be supplied by a small lamp mounted on the side of the mouse opposite the photodetector. A similar technique can be used to monitor posture, the placement of the light source being placed on opposite sides of the mouse's tail or ear. Blood flow variations during each heartbeat attenuate the light getting through and modulate the transmitter.

Transmitters are not the only electronic payloads that can be launched in a model rocket. Perhaps the simplest of all payloads is the redlight-tube light flasher that permits a rocket to be launched at night for a very unusual and spectacular sight. A night launch provides an inexpensive, yet reliable method of obtaining establish-reject data about the flight characteristics of a model rocket. The usual technique is to photograph the rocket's flaring trail with a camera set for time exposure so that the trail leaves a distinct track across the film. When the engine burns out, the light flasher can be seen and recorded on the film. Also, if the flash rate is known, it is possible to measure the rocket's velocity by counting the number of flashes during a given portion of the flight.

Even the flame trail can be used to obtain velocity and acceleration data. To do this, a strobe light is placed in front of the camera's lens so that, when the rocket is rotated at a fixed speed, the flame's track on the film is divided into a series of streaks. By using simple photometry and knowing the time duration of each flash, it is possible to measure velocity and attitude at various points along the flame trail.

The flasher also facilitates rapid recovery of the rocket after right launches. The clock the night, the faster the recovery.

Photography in Rocketry. Of equal importance with instrumentation in model rocketry is photography. Simple still cameras like the Vivitar model 390 camera, or the famous Zeiss Pancolar camera, have been used to take high-altitude photos of landscapes, hangglider development, and a host of other scientific work.

An even more exciting development came in 1968 when Estes introduced their own super-8 color movie camera. This 8-motion picture camera is powered by two small AA light cells and accepts a variety of color film media especially for the camera. A movie picture taken from a rocket in flight is truly spectacular.

The film begins with an auto-start button that moves off the screen. A few seconds later, a puff of smoke below the film signal ignition. A moment later, a large cloud of smoke and a hazy flame signal hit-off. The rocket rises with startling speed; the launch rod is gone in an instant,
in the launch crew and spectators came into view, only to rapidly disappear from the scene as the rocket soared up to apexce. The most exciting part of the flight occurs when a two-stage rocket is used to loft the Gineo movie camera. The first stage can be seen in intimate detail as it separates from the second stage in a burst of smoke and flames. The drifting, tumbling first stage, its tip sporting orange and yellow fire, is reminiscent of NASA film clips that show stage separation of full-size rockets.

MODEL ROCKET MANUFACTURERS
Below are some of the larger companies that make model rockets, engines, and electronic telemetry and photographic equipment. On request, they will forward information about their products and general literature on rocketry.

- Astro-Communications
- 4 Coleridge Place
- Pittsburgh, PA 15201
- Contact: Engineering Co.
- Box 1988, Phoenix, AZ 85001
- Estes Industries, Inc.
- Box 227
- Penrose, CO 81240
- Microdyne Electronics
- P.O. Box 477
- Rozeman, MT 59714
- Prime Recovery Systems
- P.O. Box 84
- Lansing, MI 48901

The National Association of Rocketry offers membership to anyone interested in model rocketry. The association sponsors a variety of conventions and launches. Model rocketeers compete in contests similar to those held for model aircraft hobbyists. The association also sponsors competition in research and development. For more information, write to:

National Association of Rocketry
Box 178, McLean, VA 22101

The Southwest Research Association (SRA) sponsors an annual summer study program at the University of New Mexico with emphasis on both theoretical and experimental model rocketry. Study topics include advanced mathematics, computer programming, aerodynamics, electronics, telemetry, and experimental design. Students are required to plan and execute an original research project involving some aspect of model rocketry. For more information, write to:

James P. Miller, Chairman SRA
Math Department
University of New Mexico
Albuquerque, NM 87106

One of the most spectacular developments in model rocketry is the Gineo movie camera shown here. Constructed of sturdy black plastic, camera has enough 8-mm color film to record over 20 seconds at high-speed rocket flight. Camera shown here is mounted on a carrier rocket. The stubby, four-finned section to the rear is rocket's first stage booster. In front are two engines and plastic encased film holder.

The camera can be rigged to its parachute so that it points upward, downward, or at any intermediate angle. The upward shot is an interesting sequence of the parachute unfolding, papier-mâché, and slowly descending, with and foot on the way down. Downward shots produce dramatic views of the earth as the natural oscillations of the camera continuously change the view. Some downward shots have even been known to produce a touch of nausea for the groundbound observer when the film was shown.

Model rockets, engines, and launch stands are relatively inexpensive. Rockets can be assembled from raw materials purchased as kits or bought ready to fly. Instrumentation costs can range from a few dollars for a light flash to about $20 for the Gineo color movie camera. A low-cost shack split receiver can be used to pick up the signals from most commercial model rocket telemetry telemeters (a few operating outside the CB band) and any portable tape recorder will enable the experimenter to preserve the telemetry signals. An inexpensive Polaroid camera can be used to photograph the nightire launches.

You can find out more about model rocketry by writing to one of the manufacturers listed in the box or by visiting a hobby shop that caters to rocketry enthusiasts. After you have launched a few rockets of your own, you will almost certainly want to go on to instrumentation and photography. Good luck and safe flying.
BUILD A 175-MHz PRESCALER
EXTEND YOUR 20-MHz DIGITAL FREQUENCY COUNTER TO WORK AT 175 MHz
BY DANIEL MEYER

DIGITAL readout frequency meters capable of indicating signals above 20 MHz are now becoming widely available at reasonable prices. There are a few that can reach 50 MHz, but if you have logic higher than that, the price really starts to climb.

However, by taking advantage of the latest developments in IC's, it is very easy to build a new divide-by-ten front end for less than $35. This will permit the use of electrode-range counters at frequencies up to 175 MHz.

The new type of IC uses what is called emitter-coupled logic (ECL), which operates considerably faster than the TTL types now used in most counters. The high operating speed is obtained by never letting the internal transistors be driven into saturation. This eliminates the storage time delays that slow down TTL and DTL types. These flip-flops available that can be used for counting speeds over 500 MHz. Although the Fairfield IC5328 dual flip flop used here is specified for 100 MHz, in testing the Prescaler circuit, no problems were found that would not operate to 175 MHz.

Theory of Circuit Design. A schematic of the Prescaler circuit is shown in Fig. 1. The high frequency signal is rectified at receiver, amplified by C4, and applied to the first IC, through C1 and R2, which provide the isolation and overload protection for the IC. Resistors R3, R4, and R5 are used to bias the input gate to the midpoint of the switching levels and to provide an input impedance, approximately 50 ohm—the theoretical value.

Pushing Q6 and Q7 clips any signal that may pass or exceed the supply voltage in amplitude. The first flip-flop (half of IC2) simply divides by two and passes the signal to the next, three flip-flops (second half of IC2 and both halves of IC3) which are connected to form a synchronous divide-by-10 circuit. The output signal is amplified by Q7 to provide sufficient drive for almost any type of counter.

Construction. It is best to assemble the Prescaler on a printed circuit board having the ICs potted down in Fig. 2. Be sure to observe the terminal markings on the semiconductors and not use low-power soldering iron and flux solvents to avoid thermal damage. The input and output connectors, transformer T1 and filter capacitor C4 are mounted on the metal chassis shown in the photographs. The circuit board is mounted on four spacers.

Testing, Adjustment, and Use. Apply a signal with frequency over 20 MHz and a level between 0.5 and 5 volts rms to the in-
Fig. 1. The Prescaler is essentially a high-frequency divide-by-two circuit which enables a 17.5-MHz frequency counter to indicate up to 175 MHz.

PARTS LIST

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This photo shows how prototype Prescaler was assembled in small chassis.

Put: Connect the output to a scope or spectrum analyzer. Tune or the Prescaler (V4 or R1) and adjust R1 until a pulse waveform is displayed on the scope. If it is not possible to do this, leave R1 at maximum and adjust R4 to obtain the desired display. Then, if desired, adjust R7 to reduce the output level and set the two controls on the board to produce an output with as low an input signal as possible. Print out and adjust these controls with an input signal of about 100 MHz since the adjustments are quite frequency dependent. The adjustments may be broad at low frequencies, becoming more critical as the frequency is increased.
In using the Prescaler and connecting an external signal to the input, always set the Prescaler for the maximum signal level. Even with the protective diodes, a very large voltage level at the input could damage the IC's.

When connecting the Prescaler output to a counter, note that P2 is the ground connector. Set the frequency counter to the kHz position and remember that, with the Prescaler added, all values will indicate one digit to the right. That is, with an input of 150 kHz, a conventional freewheel counter will indicate 15000 kHz. With the Prescaler added, the indication will be 0.1500 kHz. An input frequency of 175 MHz will show up as 17500 on the kHz range. If your frequency counter has a MHz range, it may be used, but you must still keep track of the decimal point mentally.

**SIMPLE THUMP AND RUMBLE FILTER**

IF YOU do a lot of home or on-location tape recording using a microphone, you know how annoying and embarrassing your tape can be when the sound played back is loaded with "thumps" and rumbling noises. Even our thumps or short rumble still can be a downright nuisance. However, there is a simple method of practically eliminating any of these noises. All you need is a square of soft foam plastic (not the rigid kind used for arranging floral decorations or the type used in many kitchen sponges that turn rock hard when dry). Cut the foam plastic to about 6" by 6". For best results, the foam plastic should be 2" to 3" thick. Just set the plastic foam pad on a solid surface, and place the recording microphone on the pad. You're ready for your next taping session. You'll be pleasantly surprised at how little background noise the mike picks up.

—Frank H. Tauber
IF YOU are guessing at enlarger exposure to save time, chances are you probably are wasting quite a bit of projection paper. On the other hand, you may be spending too much time making test strips to avoid wasting the paper.

In either case, you will want to consider building an adapter for your VTVM or TVM that indicates exposure times from 1 to 1000 seconds using the ohms scale on the meter. You have to add one more small and one long against the meter, but this will not affect conventional operation.

Well linear operation for maximum sensitivity, the 9000-ohm range of the meter adapter covers almost any situation. You can use the adapter for integrated light or the spot method. A variable-sensitivity control permits programming the meter to accommodate different paper speeds and different modes of operation. The meter also provides a direct reading of negative contrast.

Theory of Operation. The adapter can be used with any VTVM or TVM having a 10 of the center of the ohms scale and in X1 or ohm range. The basic ohmmeter circuit usually includes a range resistor (R) in the schematic selected by the ohmmeter switch.

The resistance of R decreases in direct proportion to the applied light level. The phototransistor called for in the Parts list has a very high dark resistance, fast response, and a flat color temperature response over a wide range, so substitutions should be made accordingly. Phototransistors R1 and R2 are connected across the electronic range resistor to provide the variable sensitivity. It is this that makes possible the calibration of the meter for direct readout of exposure time in the photo scale. Push button switches S1 and S2 facilitate the zero and full-scale meter adjustments.

Construction. The adapter can be mounted directly on the cover of a small plastic case, with R2 at the center and the two switches on the bottom corners. Mount 0 at another corner, while the three-wire cable should exit through a grommeted hole at the third corner. With an ohmmeter, check that resistance variation of R2 is smooth for its entire range. A 0-100 dial plate is used in conjunction with a marked knob to set R2 to any desired point. Index the pointer to zero with R1 set full clockwise.

Phototransistor resister PCl is mounted between two small pieces of insulating material such as plastic or insulation board and the sensitive surface exposed through a hole. After cementing the cable to PCl, and closing the “sandwich,” paint the enclosure (not the sensitive PCl surface) white.

If you want to illuminate the meter face for daylight operation, use cardboard or sheet metal to form a slip-on meter hood as shown in the photo. To illuminate the meter face, use a #49 pilot lamp, rated red and in series with a 73-ohm resistor, connected in parallel with the existing meter pilot lamp. Or you can use an external transformer to provide the necessary power for the lamp.

Checkout. You can verify cell linearity and meter scale reading using the enlarger aperture control to change light levels by known ratios. Set the meter to OHMS in the X1 range or range. When the meter is warmed up, depress S1 to zero the meter. Release S1 and depress S2 to set the meter to full-scale.

PARTS LIST

A. Literature phototransistors
   PC1—Phototransistor plus holder
   PC2—High-speed Shore phototransistor
   (similar to 125G26, or equivalent)
   R1—Lo-range meter type phototransistor
   R2—1000-ohm, 1-watt resistor
   S1 — Snap, normally open pushbutton switch
   S2 — Snap, normally closed pushbutton switch
   Wire—Small plastic case with cover 0.060
   plus anos, plastic leads, length of these
   2-wire, 12-24, insulated, flexible wire, plastic for PC1
   12-24, smaller gauge, optional meter
   housing and illuminator.
BUILD AN

ENLARGER
TIMER

PUT YOUR VTVM TO WORK
IN THE DARKROOM

BY ADOLPH A. MANGIERI

With R1 set to maximum resistance and the enlarger and all darkroom lights off, the cell should indicate near unity after the cell stabilizes. Avoid exposing the cell to strong room light during calibration and use. If necessary, position the meter so that stray light from the illuminator has little or no effect on meter indications.

Place a normal contrast negative in the enlarger. Turn a 35 mm negative 1½ inches between lens and mask. Move the lens aperture lever from maximum to F-5.6 to take up any backlash. With R1 set at about 5000 ohms, position the cell so that the meter indicates 4 seconds. Move the lens aperture lever to F-8 and F-11 and observe meter indications of about 8 and 16 seconds. Similarly, with lens at F-5.6 and meter initially set to 16 seconds, move the lens to F-8 and F-11 and observe indications of about 32 and 64 seconds.

Calibration and Application. To calibrate the exposure meter, turn off all light and record the setting of R1 for the exposure time that corresponds to the 12-step sequence of the guide. For a conventional test strip method, let's assume that the test strip was exposed for 15 seconds at F-8.

For the integrated light method, place the cell at the center of the projected image. Hold a ground glass plate at the enlarger lens to scatter the light. Adjust R1 until the meter indicates 15 seconds and record the setting. To use the meter at any print magnification or lens aperture, set R1 as recorded, use the light scatterer, and expose for the indicated time.

Next, set the lens aperture to F-5.6 or one stop larger. Find a second setting of R1 for a meter indication of 15 seconds. To use the meter at a setting of R1, measure the exposure time at a chosen aperture, close down one F stop, and expose for the measured time. Or, you may halve the indicated time and expose at the same aperture. Similarly, you can calibrate R1 for measurements at two stops larger and close down two stops before exposing at the measured time. It required, use these alternate calibration points to accommodate large blow-ups of dense negatives. They are also useful with enlargers having unusually small lamps.

A second mode of operation bases exposure time on a single spot measurement at the shadow area of the print. Following the procedures here in the introduction and starting with the second lens aperture, place the cell at the bright portion of the image and about R1 for an indication of 15 seconds. It's best to avoid measurements at black-out blocks which appear as black areas on the negative.

As an aid in selecting paper contrast grade, check negative contrast at half-step. Place the cell at the bright portion of the image. Adjust lens aperture and R1 until the meter indicates 1 second (reference point). Position the cell at the dark portion of the image and note the indication, say 12 seconds. Directly, negative contrast is 12. By test prints, establish your own correlation between contrast measurements and required paper contrast grade. Negatives with contrasts of 8-10 will print anormal contrast paper.

You may prefer to devise other calibration procedures. For prospectives, calibration can be based on measurements at important areas such as the subject's face. Or, you can base calibration on the areas of highlight and shadow measurements.
**UNDERSTANDING AND GETTING THE MOST FROM STROBES**

If it is a simple device, the flash tube, but it is often regarded with awe perhaps because many people don't understand just how and why it operates. A flash tube is nothing but a sealed glass or quartz tube, filled with an inert gas (such as neon) and a tube and connected to a high-voltage pulse source. When a trigger pulse occurs, some of the neon in the tube is ionized, allowing some electrons to flow through the gas. When this occurs, the remainder of the gas in the tube is ionized and the capacitor discharges quickly through the tube. The result is a flash of bright light.

The flash tube remains in the conducting state until the storage capacitor is fully discharged. Series resistor $R$ prevents the power supply from providing enough current to keep the gas ionized after the flash. This avoids what is called "afterglow", which can destroy the tube when it occurs.

**Determining Flash Duration.** When the flash tube is in the conducting state, it has a very low resistance and if a tube of short lengths is used, the value $R$ is used to determine the flash duration. An approximate equation is $T = RC/2$, where $T$ is the flash duration in seconds, $C$ is the value of the storage capacitance in farads, and $R$ is the equivalent resistance of the tube in ohms. The equivalent resistance of the tube depends largely on the distance between the cathode and anode electrodes. To the longer the tube, the higher the resistance.

For conventional photographic work, a flash duration of approximately 1 microsecond is required. For long pulse applications, a high capacitance and high flash tube resistance are required.

When the trigger is initiated, an electron in a xenon atom is raised from its "ground" (lowest) state to some excited state. The atom can only remain in the excited state for approximately 6 nanoseconds. When the atom returns to the ground state, it radiates energy in the form of light or photons. According to Planck's Law ($E = h

**Fig. 1.** In basic flash-tube circuit, C1 discharges through tube, after a trigger pulse partially ionizes gas.
frequency of the photons is directly proportional to the energy state of the electron. Since the excited states are in discrete, or quantized, energy states, the resultant photons are of discrete frequencies.

Flash tubes are usually manufactured in three styles: linear, U-shaped, and helical. Parameters are generally specified according to minimum-to-maximum voltage across the tube, minimum trigger voltage required to start gas ionization, maximum energy per flash, maximum average power dissipation per tube, and usable lifetime of tube. These parameters are determined by the tube's physical construction: arc length, tube diameter, type of electrodes, and gas pressure.

![Fig. 2. To attain necessary high voltage, doubler and tripler circuits are used in the tube power supplies.](image)

The amount of light energy released can be determined by knowing the potential energy stored in the capacitor. This can be found from the equation \( E = \frac{1}{2} CV^2 \), where \( E \) is the energy in joules or watt-seconds, \( C \) is the value of the capacitor in farads, and \( V \) is the voltage across the capacitor.

The total power dissipation of the flash tube is equal to the energy per flash times the number of flashes per second. However, the designer must be willing to trade-off maximum energy per flash for the maximum number of flashes per second so that he does not exceed the power dissipation of the tube. If maximum ratings are exceeded, the shock waves in the gas could cause the tube to crack or shatter.

**Energy Supplies.** Between 300 and 600 volts dc are required to power the most common types of flash tubes. A voltage doubler (or tripler) such as that shown in Fig. 3 will serve the purpose well. Since the capacitor must discharge quickly, its internal resistance increases the flash duration and generates heat within the capacitor. Special flash-type capacitors are available, but conventional electrolytic capacitors may be used. (However, the latter require replacement since the heat eventually vaporizes some of the electrolyte.)

Like most light sources, the lifetime of a flash tube is limited. Each time the tube is flashed, new carbons are deposited on the electrodes and cause some of the cathode material to be fragmented and deposited on the inner surface of the tube. This deposited material forms a black area near the cathode, and as the cathode element is used up, the black area grows. Eventually, the point is reached where the flash tube either does not fire or fires erratically. Depending on the tube's cathode structure, the operational life is between 5,000 and 10,000 flashes. Of course, operating a flash tube below its maximum rating greatly increases its useful life.

**Trigger Circuits.** The basic trigger circuit is shown in Fig. 3. When switch S1 is open, the high-voltage dc charges capacitor C1 through the primary of transformer.
Anominate the text and diagrams from the image.
**Initial Adjustment.** Adjustment is not critical, but it does require some patience to get the best results. Always adjust one trimmer at a time, and use a lamp load equal to about 60% of the dimmer's rated capacity. Use the following procedure:

1. Turn all all RT's and set all controls to zero.
2. Set R1 and R6 for maximum resistance and R2 for full intensity.
3. Connect the positive lead of a dc voltmeter to the wiper of Q1 and negative lead to ground. Apply power.
4. Adjust R3 to get a voltage indication of 5.5.
5. Set R2 to minimum and adjust R6 to get a 2.5-volt indication. Repeat steps 4 and 5 until R6 varies the voltage between 2.5 and 5.5.
6. Set R4 for full intensity. Set R8 for minimum resistance and R8 at 50%. Connect load to dimmer under adjustment and R1 to master position.
7. Set R7 to maximum and adjust R8 until the lamp no longer increases in intensity.
8. Set R7 slightly off zero and adjust R8 until the dimmer just begins to burn. Leave setting for about 50 seconds. If the dimmer drifts either up or down, readjust R8 until the dimming is sustained, but as low as possible.
9. Repeat steps 7 and 8 for each of the other dimmers. Make sure that dimmers not being adjusted are off.
10. Set R1 for maximum and any other dimmer to maximum (Q1 at minimum) and read the voltage as in step 3. Move the positive voltmeter lead to the wiper of Q2 and adjust R1 for the same reading. Be sure to have one dimmer set to maximum when making this adjustment.

Readjustments should not be necessary unless parts are replaced. However, if the unit receives a great deal of use, readjustment after the first 500 hours may be necessary to correct for component aging. On rare occasion, R5 may not have enough resistance to bring the blackout point of the dimmer below 1 or 2 on the knob scale. If this happens, insert a 1500-ohm, 1/2-watt, resistor in series with R6 and proceed with the adjustment. Since R11 never operates above 50% of its rated voltage, it should last many years, but a few spares should be kept on hand. The R7 controls may get slightly warm during use, but this is normal.

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**SWITCHING LOGIC QUIZ ANSWERS**

(Questions on page 31)

1. F. In this series AND circuit, all of the switches must be in the "off" or closed positions before the indicator can be fired (lamp lights).
2. F. In this exclusive OR parallel circuit, each switch arranges an indication of the condition of one of the doors (switches).
3. B. In this exclusive OR parallel circuit, only one lamp or the other, but not both, can be on at any one time.
4. G. In this inclusive OR parallel circuit, the operator of either switch, or both operators simultaneously, can turn on the motor.
5. C. Closing either switch removes the canopy first (lights the same lamp), and during the remaining switch that affects the pilot (lights the other lamp).
6. H. The first switch to be closed causes the corresponding lamp to be energized at least momentarily and prevents the remaining lamp from operating by opening the series switch. In a row (simultaneous closing of both switches), neither lamp can operate.
7. F. Any two of the three switches, at all three can operate the lamp, but any single switch cannot.
8. A. Closing either switch can turn on the lamp, and the remaining switch can then turn it off. Control of the lamp can take place in any sequence from either direction.
9. F. In this "odd parity" circuit, any one or all three of the switches can be used to operate the lamp, but no combination of two switches can.
10. D. In identical parallel branches, one circuit contains the smaller and the other the indicator lamp.
Low-Cost Electronic Thermometer

INDICATES LOCAL OR REMOTE TEMPERATURES FROM FREEZING TO 302°F

BY JAMES R. SQUIRES

Electronic thermometers have proven to be not only more accurate than the old-fashioned mercury types, they are also far more versatile. They can have more than one sensor and the sensors can be mounted almost anywhere within range with a cable connected to the control.

A circuit for a good low-cost electronic thermometer is shown below. The unit has both local and remote sensing and can operate between 32°F and 302°F in two ranges.

The thermistors are used as the temperature sensing elements to keep to a minimum the deviation of the temperature from its set point. If you measure the ambient temperature, then you will see the thermistor dropping, and, after recooling, it will indicate slightly higher than the ambient.

The two scales on the thermometer (X1 and X10) are equivalent to currents of 1 mA and 10 mA through the meter, as determined by the setting of S2. The X1 range is roughly equivalent to a temperature range of 0°F to 30°C (32°F to 122°F), while the X10 range covers 0°F to 150°C (32°F to 302°F).

In the circuit, most of the components are in series. The value of 83 is chosen so that the 1 mA meter will indicate 10 mA. For the meter used in the prototype, a value of 17.8 ohms was required for 83. Odd values of resistance for R4 can be made by paralleling higher values.

Any method of construction can be used (wood, board, panel, tube, wiring, etc.). Local thermometer TKH1 can be mounted so that it protrudes (about 5") from the chassis. The remote sensor is attached to the end of a length of two-conductor cable, with P1 on the other end. The remote sensor is not necessary, of course, if you don't want to use it.

With S3 in the X1 position, plug the remote sensor into P2, adjust S5, and adjust R8 until the meter indicates about half scale. Remove the remote sensor, and adjust R4 for a center scale indication with the local sensor. Hold the local sensor between your thumb and forefinger and note that the meter indicates upwards. Do the same with the remote sensor. The two changes should be similar in value and any deviation will be due to slight difference in scale temperature values of the two thermistors.

The meter scale is calibrated by inserting the thermistor in ice water (32°F) and adjusting the appropriate potentiometer on the probe indicated on the meter. Use boiling water (212°F) for the upper mark. To calibrate the remainder of the scale, keep the two thermistors in the same water, along with a good mercury thermometer. Soak the water, and mark the other points on the scale as the water cools. Switch S1 should be operated only when a temperature measurement is to be made. This conserves the battery and prevents any self-heating of the thermometer due to current flow.

Resistance of either thermistor determines current flow through the meter.

![Resistance circuit](image)

PARTS LIST

- S1: Snap switch
- T1: Miniature phase plug, normally closed
- M1: 1 mA meter
- P1: Miniature phase plug (plug is 6")
- RLR2: 10 kΩ potentiometer
- R1: 1 kΩ
- S1: Not used
- S3: Normally open, pushbutton switch
- S2: Shift switch
- TKH1, TKH2: Thermistors (Eureka G81082)
- M1: Snap-in chassis, two-conductor cable, mounting hardware, etc.

ELECTRONIC EXPERIMENTER'S HANDBOOK
Stage Lighting for the Amateur

CONTROLS 1500 WATTS PER CHANNEL
WITH RESET STORAGE,
CROSS FADING, AND SUBGROUPING

By Steven E. Margison

Whether it's the graveyard scene in "Our Town" or "How to Break Out All Over" in "Candide," one of the main concerns of the amateur community off-Broadway, etc. is the lighting effects. Fortunately for everyone, the days of the cumbersome, crancy electronics are gone—and replaced by the use of silicon-controlled rectifiers, triacs, and other semiconductor devices.

Many little theatre groups use the General Electric Triac modules, which are available in capacities of 8, 10 or 15 amperes. As in all things, however, there are improvements and circuit variations which can be made to enhance the overall effect. Here are some of the modifications that can be made.

The circuit in Fig. 1 shows the basic wiring of the GE Triac assembly (except that R2, D2, and D2 have been added). The added components prevent the "snap on" effect which usually occurs when the circuit is first energized.

In Fig. 1, the usual potentiometer control has been removed from the circuit, and the circuit shown in Fig. 2 is connected to the terminals marked A and B. The use of the circuit in Fig. 2 provides a master control function and permits safe remote operation since the controls are powered by low-voltage dc.

Master Control System. The heart of the control circuit is a photocell-lamp combination. When the lamp is illuminated, the resistance of the photocell goes down, and vice versa. Transistor Q9 can handle up to 1 amperes so that it can control as many as 25 triacs. Potentiometers R4 is the master control while R3 and R6 are trimmers for initial setup. Switch S2 is used to turn the control off and to select either independent or master control.

Potentiometer R7 is the actual dimmer control, while R3 and R6 are trimmers. Potentiometers R4 and R7 are mounted on the front panel; other controls are within the cabinet. Transistor Q2, preset by R2, is used to set the voltage on the independent line to the same value as the voltage on the master line.

To insure long life, transformer T1 and B2277 should be selected to give more power than required. For instance, a 10-dimmer system requires a 1 ampere transformer, but a 1.5-ampere unit is better. The current rating of the transformer for 10 volts can be found by multiplying the number of dimmers by 0.1.
Construction. Most circuit breakers are not fast enough to protect the Triacs; slow-acting fuses should be used. A good choice is the 340-type, which is the rectifier version of the conventional 3AG. A better, though more expensive fuse, is the KAA rectifier fuse.

The two transistors must be mounted on heat sinks using mounting vibration. The photoeye/lamp assembly should be mounted within the control cabinet, with the lamp leads connected through RJ9 to points A and B on the Triac module.

To avoid switching transients and radio frequency interference, use appropriate shielding and grounding in the modules and the associated wiring. Switching transients affect other dimmers in a manner called "tracking", which occurs only when several dimmers are operated at very low intensities. A slight change in the setting of one or more dimmers will correct the problem.

If there are problems with mechanical noise emanating from the dimmers, do not shock mount them to reduce the noise. This increases their internal heat and may result in early failure.

If the dimmers are not overloaded by short-circuited, the only damage they can suffer is from excessive heat. Make sure that the dimmer cabinet is well ventilated and that the modules are mounted on a heavy aluminum plate. The addition of a small quiet fan will help. The fan should be mounted to exhaust air from the cabinet and should be connected so that it goes on as soon as Triac receives power.

If desired, a set of panel lights, operating on the 120-volt dc line and controlled by a 10K-ohm potentiometer can be used. Treat each lamp as if it were a dimmer in determining transformer and rectifier capacity.

Fig. 1. Schematic of 1500-watt commercial dimmer module (except for R2, D1, and D2).

Fig. 2. Remote control circuit to operate the phase shift network in the Triac module.
Fuses For Electronics

Types of fuses and where they are used. How to select the right fuse for your circuit.

BY BUSSMAN MFG. DIVISION
McGraw-Edison Co.

FROM a strictly mechanical point of view, fuses may be placed into two general categories. The first category is the clip-in fuse, which must be placed into some kind of fuseholder or a part of clips to perform its normal function. The other category includes those fuses that have leads soldered to the end-taps and are generally referred to as "pigtail" fuses. Pigtail fuses can be soldered directly into an electronic circuit or printed circuit board, without a fuseholder device.

Time-Delay Fuses. One of the most popular fuses to use is the so-called "time delay" fuse (sometimes referred to as "slow blow"). This is a general-purpose fuse with the ability to pass heavy transient currents and yet blow with instant overload or short circuits. It is usually encased with a solderable lead, and is designed to dissipate the heat generated by momentary transient currents and is spring operated when the current is just long enough to cause the thermal alloy to melt. This type of fuse is sensitive to ambient temperature and must be derated when applied in an extremely warm location in order to carry the load current.

Fast-Acting Fuses. Another very popular fuse is the "fast-acting" or "normal blow") fuse. This is generally applied in circuits where there are no transient or surge currents to damage the equipment. This fuse generally has a single-element, wire-link construction, without any heat sinks or addition auxiliary components. Fast-acting fuses have low inrush and must be used very carefully with regard to the amount of fault load current. Quite frequently these fuses are used to provide short-circuit protection only and, therefore, can be sized at approximately 150-200% of the full load current. Ambient temperature has very little effect on the performance of these fuses.

"Very fast-acting" fuses are becoming increasingly popular for use in circuits that require extremely fast operation to protect critical components, such as rectifiers or semiconductor devices. Electronic equipment that has very little ability to withstand overcurrents requires this kind of protection. This fuse is constructed similarly to the "fast-acting" fuse except that the link is generally surrounded by a special filler material, and the fuse body is made of nonmetallic or phenolic material. The very fast-acting...
Comparing Fuse Characteristics. Figure 1 shows the operating characteristics of the three types of fuses mentioned above. Consider that all three types carry a one-ampere full load rating but, as can be observed, the blowing time for each is considerably different for a given overload current. For example, when the overload current is 2.06" (2 amperes), the time-delay fuse takes 28 seconds to blow while the fast-acting fuse, opens in approximately 1.4 seconds. A 2-ampere current, through a very fast-acting one-ampere fuse, causes the fuse to blow in 0.13 second.

It can be seen from the above that a knowledge of the circuit in which a fuse is applied is important. Will the circuit develop transient currents? How fast must the fuse operate when a short occurs? These and many other questions should be considered when initial circuit design is undertaken.

There are many fuses today which have been developed to meet special needs. Usually, the fuse dimensions or physical construction have been altered so that a special mounting means can be employed or so that an indicator can be built into the fuse to signal when it has blown.

These fuses have particular applications and are not considered to be general-purpose fuses. The fuses covered here are general-purpose types readily available on the market.

Criteria for Selecting Fuses. There are many considerations that should be given to fuse selection. Voltage and current ratings are the two most popular (often the only) parameters that are investigated when selecting a fuse. Other criteria that must be examined include short-circuit current rating, fuse characteristics, application temperature, fuseholder and mechanical dimensions of the fuse.

Voltage Rating. Select a fuse with a voltage rating equal to or greater than the voltage of the circuit. The standard fuse voltage ratings which are available for electronic fuses are 33, 125, and 250 volts. Keep in mind that a fuse with a higher voltage rating can always be used on a lower voltage circuit. For example, a 250-volt fuse can be used in a 125-volt circuit. The reverse procedure, however, can be very dangerous and should always be avoided. All 125- and 250-volt fuses have the voltage rating stamped on the end caps. If there is no voltage rating stamped on the cap, then it should be considered to be a 32-volt fuse unless reference to its symbol can be made elsewhere.

Autootive circuits use 32-volt fuses while 125-volt fuses are often applied in the

<table>
<thead>
<tr>
<th>TABLE I—EFFECT OF AMBIENT TEMPERATURE ON CURRENT-CARRYING ABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-Delay Fuses</td>
</tr>
<tr>
<td>Ambiente</td>
</tr>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>40</td>
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<tr>
<td>60</td>
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<tr>
<td>80</td>
</tr>
</tbody>
</table>

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input circuit of power supplies. Fuses rated at 250 volts, for example, may be applied in the B—circuit of a TV receiver.

Current Rating. Once the voltage rating is determined, a fuse with an ampere rating greater than the expected circuit full-load current should be selected. The generally accepted procedure is to choose a rating about 25% greater than the full-load current of the circuit, because fuses are built to carry their rated current to open at room ambient, whereas they are usually applied in some type of enclosure and the enclosure temperature is often higher than room ambient.

An important point to remember is that the voltage rating described above does not in any way affect the ampere rating. A one-ampere, 125-volt fuse and a one-ampere 250-volt fuse have identical current-carrying capacities. Only the ability of the fuse to open a short-circuit current is affected by its voltage rating.

Another frequent mistake made in selecting the ampere rating of a fuse concerns the current wave shape. Many electronic circuits have unusual wave shapes, such as those in rectifier circuits. The object of a rectifier circuit is to produce a dc voltage from an ac source; thus, the normal thought would be to select a fuse for the dc current on the basis of the dc current that is flowing. This would be acceptable if the rectifier were perfect; however, we know that in practical circuits, we do not have a perfect dc current and it is difficult to produce. Since the dc wave is not perfect, there is no true value of that wave which, in many cases, exceeds the dc current value. Consequently, the fuse must be selected for the rms value. An example of this is the case of a simple half-wave rectifier with a low-voltage dc output and an rms value of the wave shape of 1.57 amperes.

The general rule to follow is to select a current rating based on the rms value of the current. Only when the rms value equals the dc value is it acceptable to pick the fuse size based on dc current.

Short-Circuit Current Rating. Should a severe short-circuit occur in an electronic circuit, it is mandatory from a safety stanc-

<table>
<thead>
<tr>
<th>TABLE II—ELECTRONIC FUSE SELECTION CHART</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Buss Catalog</strong></td>
</tr>
<tr>
<td>Symbol</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>AGX</td>
</tr>
<tr>
<td>AGC</td>
</tr>
<tr>
<td>ABC</td>
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<td>MDC</td>
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<tr>
<td>BAN</td>
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<tr>
<td>GBB</td>
</tr>
<tr>
<td>KAW</td>
</tr>
</tbody>
</table>

*Figures Type would be GIV. **Figures Type would be MDV.
point that the fuse clear the fault without rupturing. It is for this reason that fuses are given a short-circuit rating that goes along with their voltage rating and must never be exceeded.

A normal 250 volt, 1 ampere, load current could be two amperes, full load, but when a short occurs in the circuit, the current might increase to 2000 or 3000 amperes. The fuse, in turn, must be able to open the circuit safely under this condition. Generally, short-circuit currents with magnitudes in the thousands of amperes are the exception rather than the rule in the case of low-energy electronic equipment. For most electronic devices, if a fuse of the proper voltage rating is selected, it will have an adequate short-circuit rating.

Temperature. How many times have you checked a troublesome circuit and found that the current was less than the fuse rating? Did you happen to check the temperature to which the fuse was being subjected as well? The effect of ambient temperature on fuse operation can be appreciable, especially where time-delay fuses are involved.

Table I shows the effect of temperature on the current-carrying ability of the various types of fuses previously discussed. If a time delay fuse were to be selected for operation in an 80°F ambient and the circuit current were 375 milliamperes, then the ampere rating of the fuse should be at least 2 amperes, if the same temperature and current conditions were to be imposed on a fast-acting fuse, the fuse rating should be at least 6 amperes.

There are many applications where operating temperatures can be considerably higher than ambient, especially in circuits where the temperature is controlled by a heating or cooling, as in radios, TV's, power supplies, and amplifiers.

Time-CURRENT Characteristics. Once the voltage, and current ratings are determined, a major consideration is the time-current characteristic of the fuse. The circuit determines to a great extent whether a time-delay, fast-acting, or very fast-acting fuse is the correct choice. If harmful transient currents might occur, a time-delay fuse would be needed. If the circuit is a bridge rectifier, a very fast-acting fuse would be recommended.

Dimensions. Fuse dimensions are usually considered in initial design and can be critical when space is a factor. The most common electronic fuse dimensions are 0.1" x 0.25", 0.15" x 0.15", and 0.25" x 0.15". A wide variety of mountings with a number of special features, if desired, are made for these fuse sizes.

Fuseholders. The most popular fuseholder for mounting in a chassis inside an enclosure is the ordinary Bakelite (phenolic) fast-blow which has fuse clips and wire terminals attached. For mounting the fuse in an enclosure or panel, the "panel-mounted fuseholder" is extensively used. This fuseholder has the advantage of being accessible from outside the enclosure.

Panel-mounted fuseholders with lugs to indicate a blown fuse are also available. These are particularly helpful where many fuses are used in the same area.

The plug fuse is, of course, the least expensive of a fuseholder point of view. However, a blown plug fuse is more difficult to remove from the circuit.

Table II is a quick reference chart giving their voltage and current ratings, operating characteristics, dimensions, and some of their more typical applications.
The HOW and WHY of the SCR

PRINCIPLES OF OPERATION AND APPLICATIONS OF THE SILICON CONTROLLED RECTIFIER

BY JOSEPH H. WUJEK

WHEN the semiconductor industry began to expand in the 1950's, transistors and solid-state diodes and rectifiers quickly replaced their vacuum tube counterparts in many applications. That is, until the complete transition from tubes to semiconductors was not possible because of the limitations of the latter. In 1957, however, an important step toward the goal of total replacement by semiconductors was taken when General Electric Co. introduced the silicon controlled rectifier, or SCR.

Briefly, the SCR permits the control of power in switching applications with only a small energy loss in the control circuit. By applying a signal to its control grid, the SCR is made to conduct between a pair of electrodes (anode and cathode) and remain conducting with no further excitation at the control grid. In fact, in normal operation, the grid causes the current flow that once conduction began. To stop conduction, the anode must go from a high positive potential to near zero in the phase interval of a 60-Hz power line.

The SCR performs in an analogous manner, and, in addition to the inherent improvements in reliability and simplification afforded by semiconductor, some of the faulted devices of the SCR are found in conventional systems to control individual circuits, an indispensable role for the flywheel and other vacuum tubes.

How It Works: The operation of the SCR is perhaps best understood by examining the device's pop-up junction shown in equivalent form by the two transistors in Fig. 4. Assume that the control (gate) electrode is connected so that its voltage is the same as, or slightly negative with respect to, the voltage on the anode. Transistor Q3 is cut off and very leakage current flows in the circuit. If the gate voltage is made positive with respect to ground, the forward-biased junction of Q5 becomes forward biased and Q2 begins to conduct. Meanwhile, Q4 also becomes forward biased and conducts. As Q7 starts conducting, its collector current aids in turning on Q2. Just as collector current from Q2 assists in turning on Q4.

The natural off is a form of regeneration, or positive feedback. A point is reached at which the switching action 'runs away' from the control input and becomes self-sustaining. In regeneration, Q7 and Q9 are operated at saturation, and the voltage drop from the collector of Q5 to ground is the sum of the 0.7-volt base-emitter drop of Q1 and the 6.2-volt collector-emitter drop of Q2. (The voltages are for silicon thyristors only.) Thus, the switch exhibits a low voltage drop and requires no control input power to sustain conduction.

To turn off the circuit, the current in
source. (The SCR is primarily an AC device, although in DC applications it will serve as a "latch" or memory switch, and remain conducting until the anode current is reduced or interrupted.)

The point at which the anode current of an SCR is sufficient to keep the device conducting is called the holding current. The peak voltage (anode positive with respect to cathode) at which the SCR does not undergo breakdown for given conditions of load between the gate and cathode is the peak forward blocking voltage, and is usually specified with the gate connected to the cathode through a low resistance.

The peak reverse voltage with the anode negative with respect to the cathode is also specified with the gate connected to the cathode through a low resistance.

Leakage currents increase with temperature increase and roughly double for every 10°F rise. In Fig. 1, the transistor base is shaded to distinguish between currents caused by leakage or from a triggering pulse. Hence, care must be exercised in determining the temperature rise.

These diagrams show the steps in the fabrication of a silicon controlled rectifier, as made by General Electric.
Parameters & Characteristics. If the SCR is to be intelligently employed, it is essential that the user be familiar with the device's various parameters and characteristics. These specifications are given in the manufacturer's data sheet. In choosing an SCR, first check the maximum allowable ratings, including the maximum current handling capacity of the device and the load circuit. Then, check the voltage rating for the given load current and temperature. It is generally in the range of 1 to 2 volts. The holding current specifies the load to maintain the SCR in the blocking state.

The peak voltage is the drop between the anode and cathode for a given load current and temperature. It is generally in the range of 1 to 2 volts. The holding current specifies the load to maintain the SCR in the blocking state.

The turn-on and turn-off times are specified for SCRs intended for high-speed switching. The operating conditions must be specified for the SCR to perform as intended.
Design Considerations. Once the SCR is turned on, the load current must be provided for triggering it. When used to control a circuit of the reverse-voltage type, triggering is done by firing the cathode in the phase-control method. The reverse-alternation method takes care of the current. Then all that is necessary to drive the SCR into conduction is application of a pulse to the gate when the anode is positive with respect to the cathode. A phase-control triggering scheme in its simplest form is shown in Fig. 1. By choosing the appropriate resistance and capacitance values for the network, the time or phase relationship of the gate with respect to the anode-to-cathode voltage can be determined. Household lamp dimmers often are designed this way and may employ two SCR’s back-to-back to control both ac alternations.

Because the phase between the gate and anode-to-cathode voltages determines the time the SCR conducts, the average current through the SCR is dependent upon this relationship. The firing angle can also be derived from an isolated source like a timer signal in a feedback system. When more current is needed, the control signal “flicks” on the gate with respect to the SCR’s anode to control the current flow once the SCR conducts for a longer period of time.

A transformer provides a signal variation between the trigger current and the load. The current signal might be a dc voltage, such as the on-off condition of a switch or logic circuit. A simple oscillator can be used to furnish the gate pulses, controlled by a simple AND gate.

If moderate or high currents are to be controlled, the first version of the SCR can generate high-frequency noise that will be radiated into space and picked up by power lines. These noise spikes may interfere with radio and TV reception and cause malfunctions in interference-sensitive equipment. Filters can be used in the power line to reduce this noise, but a different means exists for drastically reducing or eliminating the noise.

If the time at which the anode voltage crosses through zero and begins its swing toward positive (with respect to the cathode) can be sensed, a trigger pulse can be provided at that instant. The SCR then starts conducting early in the positive alternation and the current (in a resistive load) follows the time wave of voltage rather than suddenly jumping from leakage level to a high forward level (see Fig. 2). Several manufacturers offer IC’s designed specifically as zero-voltage detectors to use in this application.

Applications. Apart from the familiar lamp dimmer switches and speed controls for certain types of motors, the SCR is used in the home to provide control (as opposed to stopped) control of heat in electric kitchen ranges. In industry, the SCR is used to control power in battery chargers, power supplies, and machine tools. Walltherm, power regulators, and temperature control systems have been designed using the SCR as a power-control element. Among the most popular of automotive electronic ignition systems available is the SCR-Fired system and its variations. And new applications for the SCR are continuously being discovered.
BUILD THE
MONODIGICHRON

This unique electronic clock uses only a
one-digit readout and displays hours and
minutes in sequential form.

BY MICHAEL S. ROBINS

The Monodigichron is a true electronic
digital clock featuring sequential display
of tens of hours, hours, tens of minutes and
minutes on one seven-segment readout
device. Instead of displaying all four digits
continuously, in a static presentation, the
Monodigichron dynamically flashes the hours
and minutes in sequence at a rate of about
five times per minute.

The circuit uses the latest LSI-MOS in-
tegrated circuit for positive synchronization
to the 60-Hz power line frequency. Two pushbuttons (fast and slow) are pro-
vided for initial time setting.

The large, bright, incandescent readout
tube allows the Monodigichron to be read
in total darkness as well as in bright
light. The display is all electronic and
therefore completely silent. Because the
readout is a bright elementary type, any-
color light may be used.

Power for the clock is supplied by a
molded, plug-in transformer which is U. L.
approved.

Circuit Design. A block diagram of the
clock circuit is shown in Fig. 1, while the
schematic is in Fig. 2. As in most an
digital clocks, the time base is the 60-Hz power-
line frequency which is applied to a shaping
circuit (T000, T011, R9, R10, and C21) for
squaring and removal of transients. An ar-
ray of flip-flops within IC3 counts the 60-Hz
input and provides one output pulse for
every 80 input pulses (1 Hz). A binary
coded decimal counter (BCD) totals the
1-Hz pulses and provides four output lines
display of the seconds count. (Though
the seconds are not displayed in the clock
described here, they are counted in the IC.)
A BCD line provides one pulse every 10
seconds for the tens-of-seconds BCD coun-

1973 Winter Edition
An output and reset are incorporated in the three counters to cease on the next pulse after counting to 59 seconds. This output line also provides a one-pulse-per-minute signal for the minutes counter.

A third BCD counter counts and decodes the minutes and provides a one-pulse-per-minute output for the hours counter. The hour of minutes counter provides an output pulse (one per hour) and resets on the next pulse after counting to 59 minutes.

The one-hour pulse is applied to a fifth BCD counter for counting and decoding. The output of this counter operates a flip-flop for the ten-hour sound. Gauging is built into these last two counters so they will reset to one o'clock after twelve. High order zero blanking is incorporated to display 1:00 instead of 01:00.

![Figure 1: Block diagram shows basic operation of one-readout clock.](image)

![Figure 2: Most of the circuit is contained in the IC's and 7 driver units.](image)

**PARTS LIST**

- C1: 1 µF, 15 volt electrolytic capacitor thin-plate type
- C2: 0.001 µF, 10 volt ceramic capacitor
- C3: 2000 µF, 15 volt electrolytic capacitor
- R1: 5.1 kΩ, 1 watt ceramic disk
- R2: 0.033 MΩ, Releather disk (1N4004 or similar)
- D1: 5.11 V, Switching diode (1N4148 or similar)
- IC1: 7406 TTL, decade counter (Use N5010 if 1N4148)
- IC2: Digital clock II, National Semicon
ductor (74S20 and 74S572)
- Q1: 2N3904 PNP transistor (MPS572 or similar)
- Q2: 2N5050 NPN transistor (MPS572 or similar)
"Hurry-up" logic is built into the circuit to speed up the counting process when it is necessary to see the time. An externally operated switch (S2) bypasses the first divide by 60 divider, increasing the count speed by a factor of 60. Another switch (S1) bypasses the first three dividers, increasing the count speed by a factor of 3600. These two switches are used to set the clock.

Since only one digit is displayed at a time, some means is required to sequentially switch the hours and minutes lines to the display tube. This is accomplished by feeding the count outputs of all six counters to an internal output multiplexer (MUX). The MUX is essentially an electronic four-pole, six-position switch, which is continuously being operated through its six positions in the following order: seconds, tens of seconds, minutes, tens of minutes, hours, and tens of hours.

The speed and position of the MUX are controlled by its associated multiple divider/decoder and an external oscillator.
This photo shows how the parts were assembled in the author's prototype.

connected to its input. The BCD output of the MUX is fed to an on-off (input at 166) gate and then to a programmable read-only memory (PROM). The PROM is programmed during manufacture of the IC to translate the various BCD data into the seven-segment code required by the display tube.

The outputs of the MUX decoder (six but only four are used here) can be used to find out what position the MUX is in. Only one of the six is on at a time.

From the preceding description of the LSI-MOS integrated circuit, it will be noted that the multiplexer operates backwards from the desired sequential display order. Instead of going from tens of hours down to seconds, it sequences from seconds up to tens of hours. It also has the ability to display six digits, and we want only four. In this clock, the circuits external to the IC reverse the apparent direction of the MUX and eliminate the seconds and tens-of-seconds display.

Unijunction transistor Q1 operates as a free-running relaxation oscillator providing pulses about 12 milliseconds apart to drive the multiplexer divider/decoder. The period of this oscillator is determined by R5 and the parallel combination of R1 and R3. These pulses are also fed to IC1, operating as a divide-by-five circuit. On every fifth pulse, FET Q2 disconnects R1, leaving only R5 to charge capacitor C1. This increases the length of the interval between pulses 5 and 6 from about 12 milliseconds to about 750 milliseconds. The true periods of intervals between oscillator pulses are the times when the BCD output of the MUX have information to display.

By gating the outputs through Q4 with the MUX output from the multiplexer output, the strobe gate blanks the seconds and tens-of-seconds display. Additional gating (D7?) is employed to blank the display during the short intervals between 5 and 10, 10 and 15, 15 and 20 etc.

Transistors Q3 or Q4 are display drivers for the individual monochrome filaments of the readout tube. The common end of all seven filaments (pin 3) is connected to the positive side of the power supply through D7.

The power supply consists of a plug-in power transformer, four silicon rectifier diodes (D2 through D5) in a bridge configuration and filter capacitor C3.

Construction. Although the Monadigrometer can be built on a piece of perf board, a printed circuit greatly simplifies construction and reduces errors. A full pattern is shown in Fig. 3, with a parts placement diagram. Normal precautions should be taken with the close conductor spacing on the PC board. A low-power soldering iron and fine solder should be used. If a large iron must be used, a small tip made out of #14 or #12 bare copper wire should be used. Observe the polarity of diodes, capacitors, and transistors.

Although IC2 is relatively rugged, it is recommended that no soldering be done directly to the IC pins or to the board after the IC has been installed. Molex pins are suggested to form sockets for the two ICs. Do not apply power to the board until the ICs have been installed.

The cabinet for the Monadigrometer can be of any size and shape. The prototype cabinet is made of %" walnut, with 1/16" smoked grey plexiglass and brushed aluminum.

Operation. A final check should be made of the circuit and construction before plugging the transformer into an ac outlet. If everything is OK, plug in the transformer. The clock will immediately start doing strange things. Ignore them. Depress the reset button (S4) and hold it for a full minute. Release the button and observe the display for a few minutes. Depress S1 and S2 one at a time for short periods to get a feel for their operation. Then use them to set the clock and let it run.
AUTOMATIC AMPLIFIER SWITCH
CONVENIENT ACCESSORY FOR YOUR AUDIO SYSTEM

BY TOMMY N. TYLER

If you have put together a hi-fi system using separate components, the chances are that you may already have been nagged by the inconvenience of having to switch on the various amplifier each time you want to operate the hi-fi, the tape recorder, or the FM tuner (or whatever you have). Also, if you are an owner of most of all, you have probably forgotten more than once to switch off the amplifier after the last record, leaving the amplifier still on a day or two later.

Here is a simple device you can add to your hi-fi system to control the power to the main amplifier automatically whenever one of the " trách" components (such as the turntable) is switched on or off. The automatic amplifier switch, whose schematic is shown in the diagram, can be built in one evening from a handful of components. The cost should be only about 97.

Circuit Operation. Diodes D1 through D4 are connected in series with sockets S01 through S04 to the ac line. A lead connected to either of the sockets will cause a voltage drop across D1 and D2 or D3 and D4, depending on the instantaneous polarity of the power line. This voltage is applied through R3 to the gate of transistor Q1, causing full-line voltage to be applied to controlled socket S05 where the main amplifier is connected.

The circuit operates reliably for any load of 5 watts or more connected to any one of sockets S01 through S04. With a smaller load, the triggered firing current available to Q1 will retard its firing angle so that full power is not delivered to S05.

Note that the suppression capacitors larger than about 0.01 microfarad installed across the power switches of equipment plugged into the controlling sockets may have to be removed if they supply enough reactive current to trigger Q1. Such capacitors are sometimes found in turntables to suppress the noise generated when the motor is switched on; but they are not indispensable.

The effect of reactive current can also be minimized by using a plate that requires relatively high gate current for triggering. To find out really whether or not you will have a problem with reactive current, plug the turntable or other device into S01 and attach a 40- to 100-watt lamp to S05. If the lamp glows when the turntable is switched on, check for suppressors across the power switch.

Putting more in the circuit is optimal. An overload or short circuit applied to S01 through S04 could ruin one or more of the diodes, but neither Q1 nor the load connected to S05 would be harmed. Conversely, an overload at S05 would damage Q1, but none of the diodes nor the unit connected to the input sockets would be affected.

Component Selection. Diodes D1 through D4 are power rectifiers with sufficient current capacity to carry the maximum current of all the controlling devices connected to S01 through S04 simultaneously. In case

Simple circuit has 4 diodes and triac.

PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1-D3</td>
<td>3x600V, 1A glass, Silicon diode</td>
<td>3</td>
</tr>
<tr>
<td>D4</td>
<td>1A glass, Silicon diode</td>
<td>1</td>
</tr>
<tr>
<td>Q1</td>
<td>2N2222A, Transistor</td>
<td>1</td>
</tr>
<tr>
<td>R3</td>
<td>300K, 1/2W</td>
<td>1</td>
</tr>
<tr>
<td>S01-S04</td>
<td>Sockets for turntable or other devices</td>
<td>4</td>
</tr>
<tr>
<td>Wire</td>
<td>Copper, 24 gauge, copper strands</td>
<td>50</td>
</tr>
</tbody>
</table>

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they are all focused on at one time. Since the diodes are connected in series and back-to-back, they never receive more than a couple of volts in the reverse direction. Therefore, silicon diodes (for silicon power transistors connected as rectifiers) with the lowest DIU rating can be used. Be sure the rectifiers are chosen so the series and voltage drop won’t be enough to trigger Q2. Also, Q2 may have a current rating only high enough to handle the main amplifier load even though it is the controlled socket.

**Construction.** Since the amount of wiring and components required is small, a wide variety of construction methods is possible. If only one controlling socket is desired, the unit can be built inside a standard wall outlet box. Another advantage would be to use a multiple power-stripped box.

The prototype was constructed in a 3½ x 5 x 7½" box which has the minimum size for handling four controlling head sockets. Use insulated mounting hardware for the diodes and make sure wiring and connector wires extend inside the chassis to make sure there is no short circuit. Use an insulator as a check for leakage. Make sure bare leads or terminals can’t come in contact with the chassis.

Test the circuit by connecting a 100-ohm lamp in SO1. With a small load applied to one of the controlling sockets (SO2 through SO4), the lamp should remain lit. If it doesn’t, switch to a different color, which is a sign only one alternate bulb connects to which you will need an oscilloscope for further trouble shooting. With a little imagination, you can probably think of several more uses.

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**GET PC BOARD BLANK CLEANER FROM PHOTO SUPPLY HOUSE.**

Before applying the paint, most people clean the copper surface on their PC board blanks with a 40% alcohol (not ethyl alcohol) and 60% water. The etching process then takes place as usual

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**Electronic Circuit Analogy Quiz**

BY ROBERT P. BALIN

Electronic circuits perform functions that are similar in many respects to those of common mechanical devices. For example, a rectifier circuit produces unidirectional current while a ratchet and pawl produce unidirectional motion. If you can see an analogy between them, you probably have a good understanding of their operating principles.

To test your ability to identify analogies, try to match the electronic circuits (1 to 8) on the left below to the related mechanical devices (A to H) which are depicted on the right below.

(Answers below. No peeking.)

<table>
<thead>
<tr>
<th>Electronic Circuit</th>
<th>Mechanical Device</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>A</td>
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Answers:
- 8. Diode circuit
- 7. Regulator circuit
- 6. Vacuum tube
- 5. Rheostat
- 4. Vibrator motor
- 3. CJ plug circuit
- 2. AC generator circuit
- 1. High-pass filter
ELECTRONIC Wind Chimes
THE TINKLING SOUND OF A SUMMER BREEZE THROUGH YOUR AMPLIFIER SYSTEM
BY JOHN S. SIMONTON, JR.

Without overhearing a pot too much, you could call wind chimes the original background noise with no power other than the wind.

Now, you can build a set of electronic wind chimes that doesn't rely on the wind for power so you can use it indoors or out, windy days or off.

How It Works: The operation of the wind chimes as a system can perhaps be understood by referring to Fig. 1, which shows one of the three identical channels that make up the complete unit. The principal operational divisions are a random voltage generator, a comparator, and a ringing oscillator. The output of the random voltage generator is compared to the voltage developed across C as it charges through R and a pulse is generated at the comparator output whenever the random voltage is within about a half volt of the capacitor voltage. Each pulse from the comparator triggers the associated ringing oscillator and simultaneously discharges C slightly so that the voltage across this capacitor never reaches the supply level.

The complete schematic is shown in Fig. 2. The three random voltage generators are made up from transistors Q1 through Q6 which are wired to form 3 separate astable multi-oscillators. The three resistors of these astables have been selected so that their combined periods and duty factors produce a long-duration, pseudo-random pattern. The outputs of these astables are summed by passive networks (R14, R13, and R15; R16, R17, and R18; R19, R20, and R21) to produce three different randomly varying voltages. Each of these voltages is smoothed by a capacitor (C10, C11, and C12) and applied to the base 2 terminal of a medium-junction transistor. The emitter of each JFET connects to a capacitor (C13, C14, and C15) which is charged through a resistor from the supply (R22, R24, and R26).

At some random time the voltage at the emitter gets close enough to the base 2 voltage to allow the JFET to conduct. This causes the capacitor to discharge through the emitter/base 2 junction and a pulse to develop across the biased resistor (R37, R38, and R39).

The ringing oscillators are parallel-T type consisting of a transistor, a gain stage (Q10, Q11, and Q12) with a parallel-T notch filter in the feedback loops. A trimmer potentiometer (R48, R47, and R46) is used to adjust the bias of the circuit so that the circuit can be set just below the point of oscillation. Each pulse from the JFET triggers the circuit into the rapidly decaying oscillation characteristic of a chime. The outputs of the three individual oscillators are mixed in a resistor matrix (R49, R50, and R51) and capacitively coupled to the output.

Resistor R4 is used to eliminate voltage variations resulting from battery aging which would otherwise change the gain (and consequently rate) characteristics of the ringing oscillators.

Resistors R44, R55, and R56 couple some...
of the random voltage generator output directly to the ringing oscillators in such a way that when the random voltage is high, the gain and sustain duration of the oscillator is increased. This squelching action allows the sustain on some of the strikers to be considerably longer than would otherwise be possible because of the danger of the circuit breaking into continuous oscillation.

Assembly. Any assembly techniques from point-to-point wiring to real-board may be used for the usual ones but etched circuit boards will produce the most trouble-free and professional looking unit with the least hassle. Circuit boards may be etched using the full size layouts shown in Fig. 3 or purchased from the source listed. Note that two PC boards are used to keep the project small. One board mounts the three multi-filaments; while the other board contains the remainder of the circuit. Spaces are used between the boards.

Assembly of each board is relatively straightforward. Observe the polarity of all electrolytic capacitors and the center diode, take care in installing the transistors to make sure that they are properly oriented. As with most printed circuit construction, use a small soldering iron rated at no more than 35 watts and just to be on the safe side heat-shrink the leads of the transistor and diode while soldering them in place. Some of the pads on the PC board are close together so be particularly careful of solder bridges.

Mount the components on the circuit boards following the parts placement diagrams. Epoxy can be used to hold a battery clip to the larger board so that it holds the battery in the position indicated. Routen both mating surfaces with sand paper before gluing and note that the clip must be positioned so that the battery can be inserted from the side. Save the mounting of resistors R19, 250 and 251 for last and when you get to these parts note that one of the leads of each resistor passes completely through the PC board they mount on and mates with the connecting points marked "X" on the lower board.

For convenience we will put this point diagram as the smaller of the two boards the lower board and the larger of the two the RVG (random voltage generator) board. Solder lengths of #22 insulated wire to points "A", "B", "C", "D", "E", and "G" on the tone board. Make sure that the wires are long enough to reach to the corresponding points on the RVG board when the two are placed one above the other. Faster the two circuit boards together (tone board above the RVG board) using 1/4 stand-offs and 10 x 10 machine screws. Orient the two boards so that the long leads from resistors R16 and R17 pass through the "X" holes on the RVG board. Trim the leads from the tone board to proper length and solder them to the corresponding points ("A" through "G") on the RVG board.

Finish assembly by hooking up the battery connector and switch to the "A" and "X" points on the RVG board and using a
length of RG377/5 or similar thick coax or audio cable to make the connection between VCO board posts 357 (cable shield) and 357 and whatever type of plug matches the amplifier you will be using.

Testing and Operation. The unit is now ready to test. Check over all connections and component parts and snap a fresh 9-volt battery into the battery connector and close the battery case the battery holder.

Plug the output into one of the auxiliary inputs of a hi-fi or musical instrument amplifier and turn on the amplifier and input choices. Rotate the adjusting screws of trimmer controls R16, R27 and R35 fully clockwise as viewed from the closest edge of the circuit board.

Three potentiometers act as input controls for the three channels and regulate the tone between a dull "thump" and a ringing chime-like tone. One at a time, turn the trimmers from the extreme counterclockwise limits of their rotation. For some part of each trimmer's rotation, a constant tone should be heard from the amplifier and this
the tone should increase in pitch as the thumb is rotated counterclockwise. At some point before the retrace counterclockwise limit is reached, the tone should cease. After the effect of each trimmer is tested, return it to its clockwise limit. Do not pay any attention to the null strike times that you hear at this point.

Once satisfied that all oscillators are operating properly, you can proceed to preliminary alignment. Beginning with R8B, advance the trimmer counterclockwise until the point is reached at which the oscillator begins to produce a steady tone and then back all until the tone just stops. At this point you will be tuning for two things: a random pattern and the sound of the oscillator. You will hear a number of dull-sounding strikes generated by the other two oscillators which at this stage are detuned, but you should hear a single ringing tone being generated by the oscillator associated with R8B. Listen to this tone for a few minutes to make sure that the strikes are random. If sustained oscillation occurs while you are listening back off on the trimmer very slightly.

When satisfied with the setting of R8B proceed in a like manner to R47. Proceed to make sure that the strikes are random and then go to the next oscillator. When satisfied with R47 proceed to R8N.

The wind chime may be mounted in any convenient case. The case illustrated was made of sheet aluminum folded into a 4 measuring about 3 1/2" x 2 1/2" x 3". The ends of the U were secured with wood blocks having a rubber cut around each edge. The ends are held in place by #4 wood screws. Holes in the back of the case allow the output cables to pass through and mount the slide switch. When completely assembled, the slide switch is positioned in the open space above C29. The output board passes to the flat aluminum base plate with 4-40 hardware and 37 stand-offs and the bottom plate in turn attaches to the wood ends with #4 wood screws which also hold 4 rubber feet in place.

Modifications: Banging, drum-like tones are not the only possible sound, by placing the retrace trimmers clockwise, tones reminiscent of human tones or sound wood blocks can be produced. For still more strange sounds, the trimmers can be turned counterclockwise past the range in which continuous oscillation occurs.

After listening to the chimes for a while you may decide that you would like them better if the strikes were closer together or farther apart. This can be achieved without destroying the random pattern by varying the values of R22, R27, and R28. The practical limits for these resistors are from 170-000 ohms to 2.2 megohms with strike being more clearly spaced as the resistance decreases.

The pitch of the oscillator may be changed by varying the value of the resistor in the U, R47 and R8N. See example. Practical limits are about 47, 000 to 150,000 ohms with the pitch increasing as the resistance is lowered. The two resistors need not be identical.
SIMPLE
COMPRESSOR-EXPANDER

"SNAPS UP" ANY PROGRAM MATERIAL

TWO very useful techniques for the audio experimenter are compression and expansion. The compression of the dynamic range of program material (tape records) to a lower point permits maintaining a normally high modulation level without excitation, which, when used with the compressed material, restores the dynamic range. You can eliminate the expansion problem in synchronizing conventional program material with more annoying musical instrument sounds.

Creating these effects can be easily and cheaply, but it needs a bit of trial and error. Although simple in form, this circuit works surprisingly well. It gives a slight, though noticeable, amount of distortion, a certain amount of low-pass filtering, and some obvious time-related delay. Nevertheless, in all but the most critical applications, the circuit will prove very useful.

As shown in the accompanying diagram, an LED is attached to the speaker terminals on a limiting resistor and volume control of the audio system for the program material. Diodes D1 and resistor R2 protect the LED against drawing excessive current. Volume control R2 is used to vary the sensitivity of the circuit. The exact value of R1 is determined experimentally — with a high-powered audio system, a correspondingly high value of R1 is required to prevent the LED from burning out.

The audio-modulated light from the LED falls on the anode of a photo-resistor-dc, PC1. In general, without light input or transistor action, both the LED and PC1 are included in a high-light feedback loop.

With S1 switched in, PC1 is connected across the high-end of the B+ voltage divider. The output, a gate of D1 is then a function of the resistance ratio of R2 to R1. When audio-modulated light from the LED strikes PC1, which is connected in parallel with R3, the resistance increases, lowering the output voltage. With S1 or resistors, R2 and R3 are in parallel with R2 and when PC1 is illuminated by the modulated light from the LED, the comparator resistance is lowered, thus lowering the audio level at R. This effect compresses the signal.

The amount of expansion depends on the resistance values of R2 and R4. A higher value for R4 means a greater expansion range is possible. Compression depends on the resistance of R3. As this value is decreased, the compression effect is increased.

Applications. The circuit can be used as the volume control between the preamp and the power amplifier in an audio system, between the tape deck and preamp, etc.

It can also be used in musical instrument amplifiers to extend the signal-to-noise ratio or expansion of a compressed amplifier's PA system, and in making tape recordings so as to add several dB of signal-to-noise improvement.

By using a switch with a neutral center position for S1, the signal can be left unaffected. Two of these units can be connected to a stereo system, put new life into overly-compressed recordings, etc.
Direct-
Reading
Capacitance Meter

MEASURES FROM 15 pF to 10 nF IN FIVE RANGES—
PLUS OPTIONS TO 100 nF

MOST electronics experimenters have boxes filled with all types of test instruments, and, in most cases, the values are clearly marked. However, there are still quite a number of poorly marked parts whose identification has either vanished or has been lost in a drawer, making readings that can't be deciphered.

To determine unknown capacitance values, by building the direct reading capacitance meter described here, Q1 can also be used as a pulse generator with controllable repetition rate and pulse width. Capacitance can be read directly from 15 pF to 10 nF in five ranges and capacitances larger than 10 nF can be measured by indirect means.

Power is provided by an 810-ohm nickel-cadmium battery. The battery has a rated life of 500 ma-hr, but since, in this case, it provides only 2 or 4 ma, 200 hours of service can be expected.

How It Works. As shown in the schematic, the capacitance meter consists basically of a direct-reading multimeter Q2 and Q7 with Q4 driving the meter. Using Q4 essentially eliminates the effect of changing battery voltage. One of the cross-coupling capacitors in the multimeter is the unknown, while the other is of a known precision value to which the unknown is compared. The unknown is connected to terminals D and E, while the precision value (C1 through C4) is selected by switch S1A. The "off" times of Q2 and Q7 are determined by the unknown and fixed capacitance values, respectively.

The output of Q2 is coupled to another follower Q4 to integrate R12 and C5, which itself is a two-pole filter for 810 so that the meter reading is proportional to pulse rate or duty cycle (pulse width, pulse spacing). Thus, if the fixed and unknown values are equal, the duty cycle is 0% and the meter reads about midpoint. As the capacitance of the unknown is increased or decreased, the duty cycle decreases or increases proportionately and the meter reading drops or rises accordingly. The extremes at which valid readings may be obtained represent fixed-to-unknown ratios of 0.1 and 10, which points on the meter scale are equivalent 40 representing a ratio of 1.

Since these relationships hold true over a wide range of capacitance values, in switch ranges, it is only necessary to change the fixed value by a convenient whole number. Accordingly, the decade ranges are provided. In the lowest capacitance range, fixed capacitor C3 provides an output pulse width of about 10 microseconds. With each step of S1, the fixed capacitor is 10 times larger and the output pulse width is 10 times wider—except in the 1-F range. A capacitance of 1 nF in the fixed value position would result in a pulse width of 0.6 second, too long to be measured by the integrator. So the pulse width is held at 0.6 ms and the
charging time is reduced tenfold when S1B switches from B5 to B6, the latter being selected during calibration.

When S1A is in position 1, a reference capacitor can be connected externally to J2 and J3 to determine pulse width. At the same time, S1B connects potentiometer R7 to the charging circuit so that the pulse repetition rate can be adjusted. The rate range is then determined by the value of a capacitor connected to J4 and J5. Resistor R8 sets the upper limit of the rate range. It may be selected as described under calibration or as required to suit the needs of the user, but it should be no smaller than 37,000 ohms.

Potentiometer R7 is connected to provide higher repetition rate with clockwise rotation. If the builder is satisfied with the opposite direction of control, connecting R8 to the counterclockwise terminal will spread out the high end of the rate range, if R7 has a normal audio taper.

Diode D4 isolates the collector circuit of Q3 from the charging circuit of the unknown
capacitor to improve the rise time of the output pulse.

Clamp Q1 stabilizes the meter reading, with changing battery voltage by holding the peak collector voltage of Q2 at Q3 to 5.7 volts. The clamp is coupled to the two collectors through isolation diodes D2 and D3. Zener diode D1, though rated at 6.8 volts, actually begins conducting at about 4.7 volts, and does not rise above this value because the zero current required to initiate the regulating action is so small. The additional voltage is accounted for in the forward drop of D2 and D3 in series with Q1. It is the combination of Q1 that provides the short regulating action.

Construction. The capacitance meter can be constructed in any enclosure, and most of the circuitry can be assembled on a perf board mounted on the meter terminals. To minimize stray capacitance effects, certain resistance values should have been adjustable. Specifically, 68 and 612 are individually selected. Long leads should be kept on these resistors to minimize voltage changes due to heating heat. However, you want to use potentiometers for 22K,000 ohms for 68, in series with 50,000 ohm from, and for R12, a 60,000-ohm potentiometer, in series with 25,000 ohm from.

Sometimes, 2N3707 or 1N7190 may prove troublesome, as the holder is advised to obtain a few from both, preferably from a different supplier, to reduce the probability of drawing bad lot from a marginal batch.

In the prototype, all common connections, except H, were made to a ground bus which was connected to the chassis at the emitter of Q3. No ground loops were apparent from the direct connection of H to the chassis.

Calibration. Capacitors needed for calibration are given in the Parts List. Before starting calibration, note the following:

1. The terminal voltage of a new Burgess Type H16RX 8-Volt motor battery is over 9 volts. Although the capacitance meter is quite stable with changing voltage, it is advisable to turn the instrument off for about 15 minutes so that the battery voltage settles down to 8.4.

2. Be sure the instrument is not in a draft from air conditioning or windows since the slightest breeze will affect needle position.

3. After changing each capacitance value, allow plenty of time for the needle to settle down as the RC constant of the integrator is quite high. Then, using the tracer end of a pencil, very gently tip the instrument once. Even the best D'Arsonval movements tend to stick a little with dc applied, and a tap will free the needle.

4. Mark each calibration point on the meter face lightly, to permit correcting final art work until satisfied with performance.

5. When replacing the meter cover, be especially careful to ensure that the mechanical zero adjustment finger properly engages its slot.

Calibrate as follows:

1. Set meter mechanical zero at null position.

2. Turn S1 to the 1-pF position and connect an 0.01-pF calibration capacitor to H and J5.

3. Select a value for R12 that places the needle at full scale.

4. Remove meter cover and mark this point A.

5. Successively increase calibration capacitor in 0.01-pF steps, marking each point and reading with 0.1-pF, to be labeled B.

6. Add 0.05 pF for a total of 0.15 pF and mark this point C. Remove the capacitor.

7. Place S1 at 10 pF and connect a 0.01-pF capacitor to H and J5. The needle should return to the last point marked in step 5.

8. Successively increase calibration capacitor in 0.01-pF steps, marking each point and reading with 0.05-pF points to be labeled D through J1. Remove capacitors.

9. Connect a 0.1-pF capacitor to H and J5 and mark this point E. Remove capacitor.

10. Place S1 at 1-pF and connect a 1-pF capacitor to H and J5. Select a value for R6.

Perf board is mounted on meter terminals.
that places the needle exactly at the last point marked in step 5.

11. Turn off power. Allow needle to settle, and mark this point.

12. Don't check the calibration by measuring a number of suspect values on different ranges. It satisfied, remove meter face and perform final test work.

Different methods of measuring capacitance above 10 pF can be used, but here is one method of measuring values from 10 pF to 100 pF. It does not require removing the meter cover. Although, they are not included in the Parts List, a number of capacitor values in the 10-, to 100-pF range will be needed. The selection of values and capacitances are left to your discretion. One 10-pF capacitor is required for the reference. Electrolytics should be thoroughly burned. Voltage ratings should be at least 6 volts. Be sure to observe polarity. The procedure is as follows:


2. Turn the power on and set R7 to its minimum resistance. The needle should swing back and forth across the entire scale.

3. Select a value for R8 that places the left end of the swing at nearly as possible to 10. Then adjust R7, if necessary, to obtain exactly this swing. Label this point 100 on R7. Remove the 10-pF capacitor.

4. Successively connect the large-value calibration capacitors to J1 and J3. In each case, adjust R7 to set the swing as described in step 3. Then label the corresponding point on R7 with the capacitance value.

Operation. To measure capacitance values in the range of 15 pF to 100 pF, turn on the power, turn R7 to the appropriate position, and connect the unknown to J4 and J5.

Depending on your luck in selecting the IN705's, the instrument will indicate accurately to 10 pF. A value below 10 pF, however, may yield a value reading, usually just to the left of 3 on the meter. Unless you are sure that no unknown is above 10 pF, therefore, disregard any indications below 15 pF.

If the instrument has been calibrated for larger capacitances, use the following procedure (being sure to observe polarity):

1. Connect a 10-pF capacitor to J2 and J3. Preferably use the same capacitor that was used in calibration.

2. Turn R1 to position 1.

3. Connect the unknown to binding posts J4 and J5.

4. Adjust R7 to place the left end of the needle swing at 10. Read the unknown value from the R7 calibration.

Values over 100 pF can be measured with a stop watch, timing the period between upward swings of the needle. Any such measurements, however, should be considered only as estimates, because capacitors with very large values usually leak and leakages affect the time constant.

As an optional feature, the multimeter output can be used at a pulse generator. Pulse spacing is determined by the value of a capacitor connected to J2 and J3, while pulse width depends on the setting of R7. For variable 100 pF, use position 1 of R7, where value width is determined by a capacitor connected to J2 and J3 and pulse spacing adjusted by changing R7.

In Case of Trouble. Any small drift that may occur during partial perfect performance of the circuit should be considered by adjusting the meter mechanical zero, or in case of larger drift, by changing the value of R12.

Inaccurate readings are obtained, especially in low capacitance ranges, either the common lead is not connected to the chassis base so there was an internal transistor in the multimeter. To verify the performance of the multimeter, proceed as follows: Set SI to 100 pF and connect a 100-pF capacitor to J4 and J5. Connect a scope to 9 and measure pulse width. It should be about 60 ns. Now replace the 100-pF capacitor with one of 15 pF. The pulse width should not change. If it does, try replacing Q2 or Q3.

If accuracy varies with battery voltage, the cause is probable a marginal zener diode at D1. The IN705 was not designed for this application but is used here because the most suitable low current types are more expensive. Using the microoscope, check the peak output voltage of the zener at D1. If it is higher than 5.3 volts, the regulating action will suffer at lower battery voltages: try replacing D1. If the peak voltage is 5.3 volts or less but the problem persists, try replacing Q1. The meter indication should remain steady over a range of battery voltages from 7.2 to 9 volts. If the circuit is operating properly, more nearly perfect results may possibly be obtained by selecting the value of resistor R1.
BY IMRE GORGENYI

BUILD THIS
X10 AMPLIFIER TO INCREASE SCOPE USEFULNESS

A PREAMPLIFIER for your SCOPE

Fluctuations, when using an oscilloscope to check low-level signals, we wish that our scope had more gain. Suppose, for instance, that the scope's maximum vertical sensitivity is 50 mV (peak-to-peak), per inch or centimetre. With a typical low-impedance probe (10 megohms, 8-35 pF), which has an attenuation of 10:1, one scope division may represent 1.5 m Volt. Of course, the gain can be overcome by using a straight-through probe instead of the low-impedance probe. Unfortunately, this may be impractical with a high source impedance or at high frequencies.

So how do we get higher gain? We use a scope preamplifier. The low-cost preamplifier whose schematic is shown in Fig. 1 can be used to fill the probe sensitivity gap. It has a voltage gain of 10 and a bandwidth of about 3 MHz and it can be used with any scope. The integrated circuit used was developed for the 35-MHz IF range in TV and has high gain and low noise. With careful layout and choice of components, the bandwidth can readily be extended to 50 MHz or more. The IC also has automatic gain control which can be adjusted.

How It Works. The input impedance (R1) should be a few thousand ohms with the preamplifier. The output connector (J2) is a BNC type, which should be used on the scope vertical input if one is installed already there. If your scope has a pair of banana jacks, now is the time to upgrade it with a good shielded coaxial connector.

The input stage is a FET-C-Transistor. It may be necessary to add extra capacitance (C2, C3) at the input, as observed, not under "Alignment." The signal at the source of Q1 is connected to the input of J27 through C2. Resistors R1 and R3 are the load resistors for the IC, and the output signal is taken from the non-inverting output at pin 8.
Fig. 1. Preamplifier circuit uses a commercial, high-quality 45-MHz IC amplifier, with a FET input stage. The gain is adjusted by varying R6.

**PARTS LIST**

- C1—0.13 µF, 250-volt capacitor
- C2—2-4-µF ceramic capacitor
- C3, C5, C8—0.1-µF, 200-volt electrolytic capacitor
- C4—0.1-µF capacitor
- C6—100-µF, 15-volt electrolytic capacitor
- C7—8.2-µF capacitor
- C9—350-µF, 50-volt electrolytic capacitor
- C10—25-µF, 25-volt electrolytic capacitor
- B1—1372, 25W, 6.3V, 50 ma
- B2—1A774, 26W, 6.3V, 100 mA
- R1—BG330P, BEPO400P
- Q1, Q2, Q3, Q4—2N3904, 2N3906, 2N3904
- Q5—BP995, 2N3904
- Q6—BP995, 2N3904
- R1—120-ohm, 1/2-watt, 5% resistor
- R2—10-ohm, 1/2-watt, 5% resistor
- R3—1000-ohm, 1/2-watt, 5% resistor
- R4—220-ohm, 1/2-watt, 5% resistor
- R5—500-kohm potentiometer
- R6—100-ohm, 1/2-watt, 5% resistor
- R7—1500-ohm, 1/2-watt, 5% resistor
- R8—1500-ohm, 1/2-watt, 5% resistor
- R9—1500-kohm, 1/2-watt, 5% resistor
- R10—470-ohm, 1/2-watt resistor
- RFC1—MD4291, 0.015 µF
- S1—12-volt battery switch
- T1—Power transformer; capacity: 24V, 200mA
- Misc—Wiring harness, PC board, screw, solder, breadboard, flux, alcohol, R, socket, etc.

Transistor Q2 has a high input and a low output impedance and is used to couple the amplifier to the scope. The low output impedance helps to reduce the frequency limiting effect of the capacitance of the coaxial cable. The length of the output cable should be less than four inches—even less if you want to have a bandwidth of 30 MHz.

The dc voltage at pin 5 of IC1 determines the gain and, therefore, must be carefully adjusted. The upper end of R8 is held at 12 volts by zener diode D3, but a variation of only a few millivolts on pin 5 will change the gain of the preamp. So it may be necessary, after the unit is constructed, to make adjustments easier by reducing the value of R8 and adding a fixed resistor on either side of the potentiometer. To do this, once the final gain has been adjusted, yet an accurate measurement of the voltage needed at pin 5. Then use a 500-ohm potentiometer for R6 and add end resistors to make the total value 1400 or 5000 ohms. Since the IC supply is stabilized by D2, the gain setting is stable at normal line voltage fluctuation.

**Construction.** The preamp is built in two separate sections: the amplifier in one shielded box and the power supply (Fig. 2) in another. The circuit shown in Fig. 1 is built on a 3½” × 3½” piece of printed circuit board. To minimize circuit capacitances,
Fig. 2. The 15-volt, 85-mA supply to be used if not available elsewhere.

wiring is without pins. The IC socket is mounted on the non-slit side of the board after fast drilling the necessary holes. With the exception of pins 3 and 4, all holes should have the copper cleared from around them. Use a larger bit (manually) to do the scraping. Note that RC1 only uses pins one through four and 11 through 14 of a conventional 15-pin-in-line socket. Solder socket pins 5 and 12 (UC1 pin 7) to the foil. All the other components are mounted on the foil side using point-to-point wiring of the component leads and the foil as ground.

The completed board is mounted with standoffs in a 4" x 2½" x 1½" metal enclosure. Before installing the board, drill holes for input jack J1, speaker switch S1, and the power leads and coaxial cable. The last two holes must be fitted with grounding nuts.

The power supply shown in Fig. 2 is optimal if the required 15 volts at 85 mA is available elsewhere. However, if this supply is used, do not turn it on unless it is connected to the amplifier. Without D2, the supply can reach about 50 volts, which might damage electrolytic capacitor C19.

**Alignment.** Using a 10-k probe, connect the output of the preamplifier, supply power and connect the probe to a source of 1 volt, peak-to-peak, at about 1 kHz. Adjust B6 to obtain a 1-volt peak-to-peak indication on the scope.

Now connect the probe to a 0.5-volt peak-to-peak square wave and place S1 in the X10 position. You should see a 50-mV square wave on the scope. Adjust the probe frequency-compensation trimmer capacitor for sharp corners without overshoot. Switch S1 on the preamp to the X10 position and adjust C2 to obtain a clean square wave without overshoot. If C2 cannot be adjusted for the desired effect, add another small capacitor (C24) in parallel to C2. In some cases, the scope vertical input compensation trimmer may also have to be adjusted.

If you now replace the 10-k probe with a direct probe, a 50-mV signal will produce a 0.5 volt deflection on the scope. The direct output of a magnetic cartridge (approximately 5 mV) can be seen easily on the 50-mV input position of the scope's vertical input.

Do not allow the dc voltage at the input of the preamplifier to exceed the voltage rating of C1 and do not apply more than 1 volt peak-to-peak to the probe if S1 is in the X10 position.

If desired, the preamp can be built directly into the scope, with the scope's vertical gain switched accordingly, although the circuit was originally designed as an outboard unit and works well as a separately housed scope preamp.

The power supply is in one chassis (left) and the preamplifier in another. Note how component leads in the preamp are soldered together for mounting.
Build a LIGHT PROBE

ELECTRONIC HELP FOR THE BLIND

BY FORREST MIMS

IF YOU have a blind relative or friend, here is a chance to provide him with a simple-response light probe that will enable rapid location of other lights on a panel, switchboard, or multi-extension telephone; orient his position with respect to the sun; or even "read" the hands on a conventional clock.

A blind person can use the probe to detect the presence or absence of artificial illumination within a room, and it could even be employed to read the waveform on a scope.

The circuit (Fig. 1) consists of a simple (one-transistor) audio oscillator whose output frequency is dependent on the amount of

**PARTS LIST**

- **B1:** 4.5-volt alkaline battery (Eveready No. 104 or equivalent)
- **C1:** 0.01 µF, 12-volt, ceramic
- **Q1:** 2N4027, N-channel enhancement
- **Resistor, 1500Ω, 5% tolerance, close tolerance (1.5MΩ)
- **C1:** Transmission (2A-1002, HEP200)
- **C2:** Transmission (2A-1000, HEP200)
- **S1:** 3A miniature toggle switch
- **SPKR:** Headphone speaker, Micro-1/2" dia, 15" w/terminals
- **Resistors:** 1/4" dia, 47KΩ, 1/4 watt, 5% tolerance

**Fig. 1. Output frequency of oscillator circuit is determined by light striking PC1.**
light striking the sensitive surface of a phototransistor (P-C). The prototype has a frequency range of up to 55 kHz, depending on the amount of light striking PC.

**Construction.** As shown in the photograph, all components except for the battery and small switch are mounted on a 1/2" by 1/2" piece of perf board. The phototransistor is mounted at one end, at right angles to the board. Before mounting the miniature cam, position which is actuated by a cam shaft which is attached to the shaft guide. The part that goes in the tube, run the leads to about two each and secure a small portion of the connector. Push the leads through a hole in the barrel, giving the service hole in the barrel and placing the leads at right angles to the connector. A strip of cotton may be used to hold the leads secure.

The final assembly is best made in an aluminum cigarette tube measuring 1.6" by 5/8". Use the finished perf board assembly inside the tube and mount a battery clip from the 3V alkaline battery, and switch S0 so that 3V is applied through the open end of the tube. Use the photograph for this installation so that the entire assembly can be made inserted or removed from the tube.

Use a sharp punch and a stationary file to form the mounting hole for S1 at the round end of the tube. Do not use a drill for this hole, unless you have a small hole saw drill. In the aluminum tube, it is very thin and can distort very easily. To mount the 1/4" hole this metal hole can be made in the wall of the tube, directly opposite where the speaker will be located when the assembly is in the tube.

The assembly must be made so that the sensitive surface of the phototransistor is close to the open end of the tube. You can either make a small hole in the cigarette tube cap to allow the outside light to strike the phototransistor, or you can use a discarded dark glass slide having a hollow which is a light guide. The leads can be inserted from the side of the cap and the glass slide secured to the cap as the support.

**Operation and Use.** To test the module, turn on S1 and run the probe of different light sources around the tube. There will be some different levels of light, as the probe sweeps the area. If you find that the probe is too low and can't read at a moderate level, mount a small piece of polarizing material on the interior of the light hole at the cap and another small piece covering the phototransistor. This will increase the sensitivity of the phototransistor.

The light guide can be modified for special applications. For example, a miniature lamp pointed near the cap can be used to dim the light to make it easier to read the probe's ability to "read" dark areas. A blind electrical engineering student has successfully tried the prototype with a narrow-beam light collector tube to read the waveform displayed on an CRT and the panel lights on a computer board.

Components, except for battery and switch, are mounted on a small piece of perf board and entire assembly is inserted in aluminum cigarette tube with light calliminator in cap.
ANTENNA TUNER FOR SWL's

LOW-COST FRONT END INCREASES SIGNAL STRENGTH AND IMPROVES SELECTIVITY

BY CARL C. DRUMELLER

SINGLE-WAVE receivers for serious listening are usually designed for use with a low-impedance antenna input, but the included antenna, which is normally used for low-impedance loudspeakers, works best over a narrow band of frequencies. So, if you have a general coverage (0.55 to 30 MHz) receiver, it is desirable to have a low-impedance input over a wide frequency range. For this, you need an antenna tuner.

The circuit shown here provides a low-impedance input over a wide frequency range and also improves receiver selectivity. The addition of tuning and also improves receiver selectivity. The circuit resonates at desired frequency and provides low-impedance output.

The circuit is independent of transmitter-QM resistors resonate as desired haueua. J..or.nlnn w

The circuit consists of a tapped coil (L1 and a variable capacitor (C1). The latter can be switched so that it is either in series or parallel with the coil. Connected to a common length of lead to the circuit, the circuit can be tuned for resonance at the frequency of the incoming signal, with a low-impedance output. Its tuning is not critical, but it provides enough front-end selectivity to reduce undesired signal interference.

The antenna input and matched receiver input, which amounts to a selection of the signal strength. Since it is a passive, the tuner does not provide any actual gain, the increase in signal strength resulting from more selectivity of the signal power.

The antenna is mounted in a small metal enclosure along with the operational controls on the front panel. Switch S1 is used to select either series or parallel tuning of L1, while S2 is used to vary the inductance. The antenna input and receiver output connections (1) and (2) may be conventional phone connectors or BNC type devices.

The coil of C1 may be cut down and its input transformer, if one is used, should be attached. This is because, when S1 is in the series mode, the capacitor must be above ground. The coil also reduces the effect of body capacitance. The capacitor and inductor can be mounted on a small piece of perfboard with spacers to stand the assembly off its front panel. The inductor shaft should protrude through the front panel for tuning.

Inductor L1 consists of 41 turns of 20 gauge wire, covered with a 0.01 in. of a 1/2" diameter plastic tube (rubberized). The coil is tapped at 4, 9, 20, and 30 turns. The first tap, 4 turns, is used to feed S2.

To use the tuner, connect a common-length antenna to the center portion of L1 and the receiver to L2. Be sure a good ground points between tuner and receiver and between receiver and ground.

Tune in a fairly strong station between 18 and 15 MHz. and try each position of S2 with S1 in series and parallel. Tune L1 through 10 equal ranges until you reach a distinct increase in signal strength. Work your way across the various bands, adjusting the antenna tuner for a maximum signal at each point. Beyond each switch position, with frequency for totley 1e.
To maintain the performance and smooth running of an internal combustion engine, it is necessary to recalibrate it or tune it at regular intervals.

One aspect of the tuning procedure requires that the gap between the contact breaker points in the primary circuit be within certain limits. There are two ways of doing this. The first is a static method which simply measures the gap between the points when they are fully opened; the second is a dynamic method and is more accurate since it relates point gap to dwell angle.

The dwell angle is the number of degrees rotated by the distributor rotor with the points closed.

Dwell Angle. A simplified primary ignition circuit for a 4-cylinder engine is shown in Fig. 1. When the contacts (or points) are closed, energy from the battery is stored in the ignition coil primary (in the form of a magnetic field). As the engine rotates, the distributor rotor pushes the contacts apart, thus breaking the circuit. The energy which was stored in the primary is now transferred to the secondary and the large current produced is used to produce a spark across one of the 4 spark plugs.

A mechanical adjustment provided on the distributor can be used to alter the distance (or gap) between the point contacts when they are fully opened. Hence, the time during which the contacts remain closed will change as the gap is altered. For example, if the gap is increased, the contacts will remain open longer.

A d'ar voltmeter connected between the fixed contact and ground would indicate the average (area above equals area below) voltage value (e) of the waveform. Thus, the d'ar voltmeter can give an indication of the gap between the points. However, as the gap is directly proportional to the time the points remain closed, the meter scale can also be calibrated to read dwell angle in degrees.

Fig. 1. Simplified ignition circuit and waveforms for a 4-cylinder engine.
Fig. 2. Schematic of the
magnetometer. Designed for mag-
netic ground systems, it
tests 94% of US cars.

Fig. 3. Block diagram of the coordi-
natization system. The
voltmeter is switched to read
dwell or rev/min.
open one (and hence produce a voltage pulse) for every two revolutions of the crankpin. The same dc voltmeter can be used to measure engine rpm if a idle speed is connected between the input and the shaping circuit, thus becoming a tachometer.

The block diagram of a combined dwell angle and tachometer instrument is shown in Fig. 2.

To obtain accurate rpm indications, the input pulse to the tachometer must have constant amplitude and constant width, hence the need for the pulse-width stabilizer.

Circuit Details. The instrument to be described, and shown in Fig. 3, is designed to operate with engines where the negative terminal of the battery is connected to ground. Over 80% of U.S. automobiles manufactured since 1950 fall into this category, while over 80% of imported cars also have negative ground electrical systems.

Converting the complex waveform from the distributor into a relatively clean one is accomplished by processes of limiting, integration, and regeneration. Networks R1C1 and R2C2 form a pair of integrating networks. Diode D1 rectifies most of the negative components of the waveform while overdrive diode D2 limits the positive swing to 5.3 volts.

The double integration necessary to remove the ringing from the distributor waveform produces a rather slow-rising and even
d.c. to a.m. conversion as shown in Fig. 4. To overcome this, a waveform generator or Schmitt trigger circuit, consisting of Q1 and Q2 and associated components is used. Q1 is normally off and Q2 on. The value of R4 is chosen to reduce the hysteresis gap to 0.4 volt. Transistor Q1 turns on when the voltage at its base reaches 4.2 volts and turns off again at 3.8 volts. The entire cycle is divided into 25 levels, each with a hysteresis gap, producing a waveform at the collector of Q2 with the exact duty cycle of the distributor waveform. The rise time of the waveform at the collector of Q2 is 100 microseconds.

Transistor Q5 acts as an inverter driven either into saturation or cut-off depending on the state of Q2; hence, the rectification at the collector of Q4 are well defined. A fraction of the output from Q5 is tapped off by variable resistor R11 and sent to the meter circuit for dwell measurement. The full output from Q3 is differentiated by C3 and R13 to provide the trigger signal to switch on Q7.

The pulse width standardizer (Q4 and Q5) is a monostable multivibrator energized from a regulated supply.

Normally Q4 is off and Q5 conducting, Q4 being brought into conduction by the leading edge of the waveform from the collector of Q3. The stable time of the multivibrator is determined by R15 and C3. With the values shown, the output pulse has a width of 90 microseconds and an amplitude of 8.3 volts. Diode D1 protects the base-emitter junction of Q5 against reverse breakdown when Q3 comes into conduction.

The rate meter circuit consists of C7, D4, D5, C6 and R18. Each pulse from the monostable multivibrator damps wave charge into C5 via C7 and D5, thus a dc voltage builds up on C5 which is measured by the voltmeter. With the components shown in Fig. 3, a dc voltmeter having a sensitivity of 0.1 volt full scale, connected across R18, can be linearly calibrated to indicate RPM with a full-scale deflection of 3000. This assumes that the input resistance of the voltmeter is considerably higher than the value of R18. If more than one rpm scale is required, a switch (S2) can be connected as shown in the diagram to introduce different values of R18 into the circuit. Another switch (S1) can be used to select different values of C7 so that the same rpm scales can be used for 4-, 6-, or 8-cylinder engines.

The dc voltmeter consists of FET differential amplifier Q6 and Q9 and provides the necessary high input resistance to avoid loading the rate meter. A pair of emitter followers, Q7 and Q8, provide the low

---

**Fig. 4. Typical waveforms found on a 4-cylinder engine. To see ringing and steep rise times, a high-quality scope is needed.**
hoop conductance necessary to drive meter $M_1$. The FET's and associated transistors should be placed physically close to each other to achieve optimum temperature compensation. The gain of the differential pair is approximately 10 and $R_{23}$ is used to balance the currents in the two halves of the circuit to produce zero meter deflection for zero volts input. Potentiometer $R_{52}$ is adjusted to calibrate the rpm scales while $G_{10}$ is used to smooth the meter needle fluctuations when measuring dwell angle at low rpm.

The regulated power supply enables the instrument to operate directly from the engine's 12-volt battery. Zero deflection $D_6$ acts as a 10-volt regulating element providing the necessary constant supply voltage for $Q_1$, $Q_4$ and $Q_5$, thus making the accuracy of the instrument independent of normal battery voltage fluctuations.

Construction: Almost any type of construction may be used, PC or perf board. Remember that vibration comes into play during automotive use so take appropriate care in mounting components. In the prototype, a 4 1/2" by 21/4" board having panel through holes 0.15" apart was used. All components except the motors and meter were mounted on the single board. The overall size of the project is determined by the meter used.

If the instrument is to be used on only one type of vehicle (say a Studebaker), then $S_1$ can be eliminated and the required value of $C_7$ is used. If only one rpm range is needed, then $S_5$ can be eliminated after selection of appropriate $S_8$. The reset switch actually on the front panel will then be replaced with switch $S_2$.

The only critical components are the capacities selected for use as $C_2$. These must be of high quality, therefore silver mica or polystyrene capacitors are used.

Another thought worth special mention is the meter. Electrically, it must have a full-scale deflection of not more than 1/2% to give the correct indications with the values shown in the diagram. Of course, if a more sensitive meter is available, it can be used provided the values of $R_{22}$ and $R_{27}$ are changed to match the full-scale deflection. The physical shape and size of the meter are not critical, they depend on individual preference or on what is available. However, because the meter in the backlight of the instrument, it should be chosen first as it will determine the cabinet size. Always keep in mind that the meter does undergo some physical vibration in use, so a tant-hand type is preferred. Another word is in order regarding the meter scales. Preferably there should be two linear scales, say 0-4 and 0-1. The 0-1 scale is used with a $\times 100$ factor to give 0-1000 degrees dwell. The 0-3 scale is used with either a $\times 1000$ or $\times 2000$ factor to provide the 0-3000 and 0-6000 rpm readings. Readers with a steady hand may want to open their meters and mark their own scales.

Waveforms: The waveform shown in Fig. 4 will be found useful when trouble shooting the circuit. They were observed with a 50-MHz oscilloscope using a 1-Megohm, 5-PF probe. The amplitudes given for the distributor waveform are approximate since they vary with different types and makes of engines. The distributor firing waveform shown is fairly typical for all engines. Note that the amplitude and width of the pulses appearing at the collector of $Q_5$ are independent of engine characteristics and performance, only the number of these pulses per minute is significant.

Calibration: Only two adjustments are required to calibrate the instrument after completion. The components values used in Fig. 4 will provide two rpm scales, 0-3000 and 0-6000. Should different full-scale ranges be desired, the values of $R_{28}$ and $R_{29}$ can be determined accordingly. A one watt generator capable of delivering at least 15 volts peak and a square wave generator capable of delivering at least 20 volts peak is necessary. If the frequency of the generator is not known accurately, a frequency counter will also be needed.

Connect the dwell hack to a source of about 24 volts dc, switch to the rpm mode and connect the output of the audio generator to the input of the instrument. Adjust the audio generator amplitude for either 15 or 20 volts peak and the frequency to 100 Hz. This frequency corresponds to 1500 rpm and for 4-cylinder engines, in order to twice the full scale rpm desired divided by 60. Adjust $R_{32}$ to obtain full scale deflection.

For dwell calibration, disconnect the audio generator from the instrument, switch $S_2$ to "dwell" mode. Meter should now indicate full scale. If not, adjust $R_{31}$ to obtain full scale deflection.
Versatile IC Timer

From 10 microseconds to 1000 seconds using one IC and four components

BY WALTER W. SCHOPP

There are timers that are initiated by the closing of a switch and there are timers whose cycles are started by the opening of a switch. There are circuits that energize a relay to close contacts and circuits to de-energize a relay—sometimes during the same timing cycle. Described here are circuits that perform many of these basic timing functions, all using a few cost-rate-to-apply integrated circuit. Some of the circuits are operated by switches, some by touch plates. In all cases, once the cycle has been started, the timing cannot be affected by further triggering until the cycle has been completed.

The integrated circuit is a Signetics type 555. It is available from suppliers such as Poly-Paks, Solid-States Sales, etc. The power supply for the timers can be obtained from a battery or an unregulated supply of 10 to 18 volts.

The accuracy of most timing circuits is affected by voltage variations in the supply voltage. The charging rate of the timing capacitor varies with respect to the fixed trigger point of the device (transistor or UFT) used.

The internal circuitry of the 555 timer IC. Besides timing, the IC can be used as an oscillator and can operate in both monostable and astable modes. The output can sink or source 200 mA or drive TTL...

at the input of the timer. In the circuits presented here, the charging rate of the timer capacitor and the threshold trigger point of the comparator are both directly proportional to the supply voltage. This means that the power supply voltage has little effect on the timing accuracy.

Timing cycles varying from microseconds to hours can be obtained by changing the time constant of the resistor-capacitor circuit. The chart shows the values to use for \( R \) and \( C \) for different time delays.

The relay used in these circuits can be any low current sensitive relay such as S1214A, 4F-5000 or 11F-2200 C171.

Required \( R \) and \( C \) for timing intervals from 10 microseconds to 1000 seconds.

![Graph for Required R and C](image-url)
BUILD THE
DECID-O-TRON

LET ELECTRONICS HELP YOU MAKE DECISIONS

EVERS, top-flight executives sometimes have trouble making decisions. If they don't have a flip-flop, dollar handy, or a solenoid, they may need a "Decid-o-Tron." This battery powered device can be used anywhere to help the undecided take the final step.

PARTS LIST

- R1 - 1.5 volt C, 4 (4 needed)
- C1 - 220-μF, 5-volt electrolytic capacitor
- C2 - 1 μF, 40-volt electrolytic capacitor
- D1 - 1N34A, silicon diode (NEPH102)
- H1 - 6V6, pentode
- IC1 - R2L 1K 741 (Motorola MC741)
- Q1 - transistor, transistor (NEP150, 2N2943)
- Q2 - transistor (NEP420)
- R2 - 4.2K, 1/4 watt (NEPH500)
- R1 - 0.1K, 1/2 watt (NEPH500)
- R4 - 100K, 1/4 watt, 1%, resistor
- R2 - 10K, 1/4 watt, 1%, resistor
- R3 - 10K, 1/4 watt, 1%, resistor
- R4 - 5K, 1/4 watt, 1%, resistor
- R5 - 2.2M, 1/4 watt, 1%, resistor
- R6 - 750K, 1/4 watt, 1%, resistor
- S1 - normally open pushbutton switch
- S2 - normally closed pushbutton switch

Fig. 1. Decisions are made by random toggling of flip-flop through operation of S2.
How It Works. The heart of the circuit (Fig. 1) is an JK flip-flop whose outputs can be in one of two stable states, high or low. Each output controls a lamp driver (Q2 or Q4) and one only one flip-flop output is positive at any one time, only one lamp can be lit at one time.

With pushbutton switch S7 closed, Q7 and Q9 operate as a conventional relaxation oscillator. This signal drives Q2 into saturation, causing a voltage of 17 volts to appear at its plate. The negative-going pulse triggers the flip-flop.

If S7 is first closed, and pushbutton switch S2 is opened, capacitor C7 starts to charge up and the voltage across C7 is reduced. This lessens the charging current for capacitor C2 and reduces the frequency of oscillation in the point where it stops. This is what provides the "division." 

Resistors R70 and R71 are used to reduce the signal on Q7 and Q9 and the elements of Q2 and Q4. This is necessary since the lamps have high-resistance current when each resistor limit current to about 20 mA.

Construction. Although any type of construction can be used, the best method is to fashion a PC board using the foil pattern and component layout shown in Fig. 2. Mount the board in a suitable chassis with the lights and pushbutton switches on the front panel as shown in the photograph.

Observe polarities on semiconductors.

The lamps are connected in the center of the chassis with short lengths of hookup wire being used to connect the PC board to the lamps or other components.

Operation. With S7 depressed for some short period of time, the two lamps should illuminate. In this mode, the circuit is capable of making a decision. Well S7 still depressed, press S2. After a few moments, the two lamps will alternate slower and slower, finally, only one lamp remains lit.

Is the output interlocked? We asked the Decision-O-Tron that very question, and S7 of the listener said, "Yes."
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Record 4: Broadway (L6221) & (L6222)

Special School and Library Offer

SPECIAL SCHOOL AND LIBRARY OFFER

NOW...
VEHICLE ALARM SYSTEM

KEYLESS SYSTEM OFFERS THREE OPERATIONAL MODES

BY FRANK J. DIELSI

With automobile thefts increasing in spite of the best efforts of Detroit in providing locking steering columns and buzzer warning systems on the situation— it is apparent that a reliable alarm system is necessary to protect not only the vehicle but its contents as well.

Most available alarm systems require the installation of an outside "pick proof" lock with an additional key that has to be carried around and separate switches installed at each door, the trunk, and the hood. Unfortunately, none of these systems are still vulnerable because the vehicle's batteries can be disconnected simply by reaching under the car and lifting the cable.

The alarm system described here eliminates all of these problems. It is operated by the switch on the door which turns on the alarm light as by switches inside the door and trunk if present. Installation is very simple since only a wire of the car's electrical system has to be modified. The alarm has a self-contained battery that is constantly trickle charged, and the alarm switch may be hidden in any convenient location in the car. When armed, the alarm disables all other electrical systems in the car including the starter, ignition, and lights; but it does not draw any current until triggered. To prevent triggering the alarm by the driver, a 10- to 15-second time delay is used, allowing ample time to arm the system before leaving the car and closing it upon returning. It would take much longer that 30s for an intruder to utilize the system and find the switch— even if he knew that the car was protected by an alarm.

The driver also has the option of a mode of alarm operation to suit different situations. In mode A, when the door, hood, or trunk is opened; after the initial delay, the alarm sounds for 30 seconds and then goes on and off at approximately 5-second intervals until the door is closed, the door,
switch is turned off, or the batteries are exhausted. If the door is closed after the alarm starts, it sounds for 60 seconds only and then stops, and is ready to sound again when a new threat occurs.

In mode 1, after the initial delay, the siren sounds for 60 seconds only and then stops whether the door remains open or is closed. If the door is closed, the alarm resets. This mode is suitable for parking in enclosed areas where a 60-second siren is sufficient to highlight an intruder with only minimal excessive noise.

In mode 2, after the initial delay, the siren sounds continuously until the driving switch is turned off or the batteries are exhausted, whether the door remains open or closed. If the owner is within hearing range, mode 2 can be used.

How It Works

The system (see Fig. 1) was designed for use with a negative-ground battery system, but it can be changed for use with a positive ground by reversing the polarity of all the devices and the auxiliary battery.

Thermostatic relays are used because they are simple and responsive. They are temperature compensated and unaffected by mechanical vibrations.

When the arming switch (SW) is on and a door is opened, the current from the car battery will flow to terminal 1 through FL, DI, K1 heater, D4, and the variable time-delay control, R1, to terminal 2 where the circuit is through the normal vehicle wiring of the door and door switch to ground. If the car battery is disconnected, the current will be supplied by the auxiliary battery through F2 and D3. Most of the battery voltage of this series circuit will appear across the heater element of K1 because it has a much higher resistance of about 70 ohms in relation to about 2 ohms cold resistance of the heater. After the delay interval, the normally open contacts of K1 close and K2 is energized. Relay K2 locks in through one set of contacts and supplies voltage to the siren through the other set. If terminal 6 is connected to 5 (mode A) the heater of K3 is energized. After 60 seconds, the contacts of K3 open to de-energize K2, turning off the siren and the heater of K3. When the heater of K3 cools (about 5 seconds), its contacts close, energizing K2, the siren and K3's heater. Since the heater hasn't completely cooled, the contacts will again open in about 7 seconds. This cycle continues until the door is closed to turn off K1. Relay K2 remains locked in until the contacts of K3 open to reset alarm.

In mode B, terminals 6 and 7 are connected together. After K1 and K2 are energized, K3 will operate after 60 seconds to de-energize K2. If K1 is still on, the K3
Fig. 2. Circuit can be mounted in any enclosure which will fit conveniently in vehicle. The arrangement shown here used 4 x 5 x 6 in. box. Hide the unit as carefully as possible and try to conceal wiring.

The heater will stay on, keeping K2 and the alarm off. If the door is closed, the K1 contacts open but K2 is locked in until the 60-second delay of K3 is completed. Then K2 is de-energized and the alarm is reset.

In mode C, K3 is never energized so that once K1 is energized, K2 locks in and the system works continuously.

Diode D3 prevents the auxiliary battery from discharging into the car's electrical system when the car's battery voltage is below that of the auxiliary battery (charging moment in). Diode D3 protects the auxiliary battery from overcharging while D4 keeps the car battery from holding K1 closed after the arm switch is turned off. Diode D5 protects contacts of K3 from inductive surge when K2 is de-energized.

The eight rechargeable D cells in the auxiliary battery can operate a 5-amper e a.m. for about 15 minutes and should have a useful life of at least 50 discharge charge cycles. The charging circuit through K2 limits the charge current to 0.5 ma with an alternator voltage of 14.5 volts and auxiliary battery voltage of 8.8 volts. When the auxiliary battery is charged up to 12 volts, the trickle current from the alternator is limited to about 35 ma. The fully charged auxiliary battery does not draw any current from the car's battery because the 0.6-volt difference between the batteries is less than the 1.5-volt drop across D2 and D3. At 8.8 volts, the auxiliary battery will charge at about 0.2 ma from the car's battery.

**Construction.** The complete unit, including the 8-cell auxiliary battery, can be enclosed in a 4" x 5" x 6" box as shown in Fig. 2. The layout is not critical and can be arranged to suit the space and mounting conditions of the car. The two stud-mounted diodes (D1 and D2) are mounted on a 4-inch aluminum panel that also holds the sockets for relays K1 and K3. Switch S1 should be connected to terminals 1 and 2 with No. 12 (or larger) wire and to terminals 3 and 4 with No. 18 wire.

**Installation.** Hide the alarm unit as well as possible and disguise the wiring so that it looks like normal ear wiring. The original ear horns are not recommended for the alarm because their location makes them very vulnerable. Two small horns can possibly be hidden in different locations instead of one large siren.

To test the auxiliary battery, remove fuse F1 and turn on the alarm with the door open.

The only part of the car's normal wiring that has to be changed is the single wire that connects the battery to the headlight switch, ignition switch and fuse block. This wire can usually be taken at the headlight connector or at point on the horn relay. The normal connections to the alternator voltage regulator and starter solenoid should remain on the battery side of the alarm system.
PICK YOUR OWN CHANNEL FREQUENCIES USING THIS SIMPLE DESIGN METHOD

C H A N G I N G colored lights that keep time with the music—the color organ—are a natural accompaniment for a good stereo system. The possibilities are even greater with the newest quadraphonic systems—surround sound and surround light!

There are many types of multi-lamp color organs, ranging from simple LC or RC passive filters which drive LEDs or LEDs. The passive filter is the least expensive but requires a minimum of audio power. Active filter circuits are preferable but they are often costly. They need not be, however. If you use the simplified circuit design described here, 15 new parts are used in this design. A three-channel color organ should cost less than $30. It will be less if some of the parts are available in the junk box.

How It Works. The circuit shown in Fig. 1 is for one channel only. Simplified design calculations will be given to add any number of channels for any center frequency within the audio range by changing three capacitors and adjusting a potentiometer.

The audio input signal is coupled to the color system through transformer T1 and drives transistor Q1, a frequency selective amplifier. The amplitude of the output of the stage depends on the input frequency. If the input amplitude is held constant, however, the higher the center level is set (by R2), the more often the channel lamp will come on.

The output of Q1 drives an SC2 which in turn through Q2 which is used to buffer the output of Q1 from the relatively high level of the SC1. Since although about 10 mA may be required to drive the SC1, only about 0.1 mA is required at the input to Q2. The SC1 is turned off by using AC at the supply. That is why the AC voltage passes through Q2, the SC1 turns off and waits for the next trigger signal from Q2.

FILTER CALCULATIONS

Assume for Q1: V1 = 10 V, Ic = 8 mA;  
Vcc = 20V, beta = 100.

R4 = (V1, Vcc) = (20-10)/.008 = 1250 ohms (use 1/2 watt)

R5 = (V = .8/10) = 8.8 ohms (use 500 ohms)

FILTER CAPACITORS

Q1.C1, C2, C3 = 2000

- 33000 - 0.05 pf

- 33000 - 0.06 pf

- 20-1000 = 0.02 pf

- 20-4000 = 0.1 pf
Fig. 1. Active filter (Q1) is buffered by Q2 and drives the SCR to energize lamp connected to socket.

PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>See text</td>
</tr>
<tr>
<td>R1</td>
<td>2N3721 transistor (see text)</td>
</tr>
<tr>
<td>R2</td>
<td>2N3717A transistor (see text)</td>
</tr>
<tr>
<td>R3</td>
<td>100,000-ohm resistor</td>
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<tr>
<td>R4</td>
<td>10 kΩ resistor</td>
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</tbody>
</table>

Circuit Design. Almost any npn transistor can be used for Q1 and Q2, as long as the one for Q1 has a minimum beta of 50 and for Q2 a minimum beta of 100. The SCR should have sufficient power rating to operate the lamps to be used. If lamps with higher voltage ratings other than line voltage are used, the rating of the SCR may have to be changed. For very large loads, transistor Q2 should have a high output and R9 and R7 may have to be decreased in value to provide extra drive.

Simplified calculations for the important elements of the active filter are shown in the text. Calculations for R9 and R4 are used if a transistor other than the 2N3717A is used. These equations show a simple method of calculating the required value of the filter capacitors (C1, C2, and C3). The examples shown are for 80 Hz, 400 Hz, 1 kHz and 4 kHz, though any other center frequency can be selected. A typical 20-volt power supply is shown in Fig. 2.

Operation. For each stage of the color organ (as shown in Fig. 1), when power is applied but without an input signal, the potentiometer R5 is adjusted until the filter starts to oscillate and the associated lamp is turned on. Then R5 is backed down until the lamp goes off. If desired, once the correct setting of R5 has been determined, the resistance values measured from the input to the ends can be used to determine fixed resistors to substitute for the potentiometer. The channel is then left a signal from the 8 volt output of an audio amplifier.

If very high volume is required from the speaker, insert a resistance between 17 and 100 ohms in series with the input of T1 to remove the distorting effects of saturation of the transformer.

Lamp Power. If 117-volt line power is used for the lamps, an isolation transformer of the necessary wattage is suggested to prevent accidental shocks. In beds such as this, where the power is ac, it is always best not to use a metal chassis, but if you do, make sure that all wiring is connected to insulated legs of terminal strip. Under no conditions should the metal chassis be used as a common return.

If low voltage lamps are used, acoustically heavy-duty filament transformer is ideal. Make sure that the total lamp wattage does not exceed the ratings of the SCR or tank and transformer.

Fig. 2. Simple power supply delivers about 20 volts dc for the color organ.
BUILD A COSMOS DIE

Learn to use this latest extremely low-power logic

By MICHAEL S. ROBBINS

While power supply requirements are concerned, today's digital integrated circuits are amazingly economical. For example, TTL gates use 3.8 volts with each gate requiring about 1.5 mA, DTL gates use a 5 volt supply and require about 4 mA per gate, and HTL uses 5 volts at 3 mA per gate. The new COSMOS gates, however, require only 6.0 volts maximum at 5 volts and can operate between 3 and 15 volts.

COSMOS is an acronym for complementary-symmetric metal-oxide semiconductor. RCA actually calls them Bimetallic MOS, while Motorola calls them MF MOS. The technology evolved in an outgrowth that used to produce the more conventional metal-oxide field-effect transistor (MOSFET).

Besides taking very little power, the individual COSMOS elements are so small that many of these devices can be packed on a single chip than conventional bipolar devices. As an example, consider the complexity of a single transistor on one chip of a complete clock on a single chip. One standard COSMOS device (by RCA CD4010AY, contains 14 Hf-MOS and with a 16.384-kHz input, will divide down to 1 Hz. Power consumption of this chip is less than 0.5 mA at 5 volts.

Electronic experimenters will want to work with COSMOS units to get to know how they operate and learn some of their many uses. One way to get started, is to build the random-digit generator shown in Fig. 1. To make the project more interesting, the circuit forms the equivalent of a divided die by randomly displaying digits 1 through 9 on a small seven-segment LED readout. Two COSMOS 10's and a single bipolar transistor are the only active elements.

Circuit Operation: The 15-kHz oscillator drives a single-chip counter-decoder which normally would indicate from 0 to 9. However, at the seventh input pulse (which would attempt to cause the LED readout to go from 6 to 7), a reset pulse is given.

Fig. 1. Circuit includes a 15-kHz oscillator driving a counter-decoder.
Fig. 2. Actual circuit for a single die. Two gates of IC1 form the 15-kHz oscillator. Its inverter provides a reset signal. IC2 drives the LED readout, turned on by Q1 biasing.

 PARTS LIST

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>9 ohm 12-volt tantalum button</td>
</tr>
<tr>
<td>C1</td>
<td>220-mf disc ceramic capacitor</td>
</tr>
<tr>
<td>R2</td>
<td>1-mF, 100-volt miniature electrolytic capacitor</td>
</tr>
<tr>
<td>IC1</td>
<td>COSMOS dual 3-input NOR gate plus inverter (RCA CD4009)</td>
</tr>
<tr>
<td>IC2</td>
<td>COSMOS 4-input encoder/decoder (RCA CD4034)</td>
</tr>
<tr>
<td>LED1</td>
<td>Seven-segment miniature LED readout (Monaco MAN-3M)</td>
</tr>
<tr>
<td>Q1</td>
<td>2N3904 transistor</td>
</tr>
<tr>
<td>R1,R2</td>
<td>100,000 ohm, 1/2-watt resistor</td>
</tr>
<tr>
<td>R3</td>
<td>47.000 ohm, 1/2-watt resistor</td>
</tr>
<tr>
<td>S1,S2</td>
<td>Single-pole, normally open pushbutton switch</td>
</tr>
</tbody>
</table>

Mask, cover, battery connectors, battery holder, wire, hardware, etc.

used to reset the counter to zero. This reset, plus the blanking circuit, keeps the counter decoder to limit the display to the digits 1 through 6.

The actual circuit is shown in Fig. 2. ICJA and ICJIB, in conjunction with R1 and C1, form the 15-kHz oscillator. Inverter ICJC provides the reset. When the center bar of the LED display (segment g) goes off as the display attempts to go from 0 to 7, the voltage present at segment g suddenly drops to zero. This pulse is differentiated by C2 and R2 and changes the inverter to reset the counter (via pin 13). IC2 is a COSMOS divide counter that takes pulses at its pin 1 input and converts them to the correct signals to drive the 7-segment readout.

The common-cathode terminal of the LED readout (pin 5) is connected to transistor switch Q1. When normally open push-button switch S1 is closed, power is applied to the oscillator and IC2 causing the counter to cycle through its 1-to-6 sequence. When S2 is closed, the 15-kHz oscillator is stopped so the counter-driver holds whatever digit it has reached. Simultaneously, S2 biases Q1 on completing the LED circuit. This causes the LED to glow to indicate the random digit.
Construction. The components for a single die can be mounted on a PC board such as that shown in Fig. 3. Sockets may be used for the IC's, and male pins for the LED, though they can be soldered in place. Care should be used when handling the IC's. Although they have built-in static protection, the oxide gate-insulating layer can be destroyed by static electricity. Contact with the board, plastic, conventionally used to package transistors should be avoided. The black foam used to pack MOS devices is conductive and will not cause any harm. It is suggested that the soldering iron used have a three-wire line cord and a grounded tip. The plastic housing the LED may also have a low melting temperature, so take care of soldering this component in place.

The completed board, as pair of boards if you want a set of two dies, can be mounted in any suitable chassis, with only the LED candle, exposed through a cutout and the pushbutton switches mounted on the front panel. If you are making a pair of dies, a single switch can be used for S1. Any 5-volt battery may be used as the power source.

Operation. Depressing S1 initiates the oscillator and counter and should be kept depressed during the entire operation. When S2 is depressed, the oscillator stops and the LED will indicate the correct digit. Due to the reset system used, an omission the LED will not display a digit. This is a "no digit" condition and if it occurs, S2 should be released, left open for as long as desired, and then depressed again.

Photo shows how components, including battery and switches, mount on board.

Fig. 3: Actual size foil pattern for a single die and the component installation. Take care in handling COSMOS IC's. They can be damaged by static electricity.
MUST YOU RESTRICT your trailer handing to daylight hours because you don't have the safety lights required by law for night handing? If so, a simple converter circuit, installed in your trailer lamp circuit, can allow any single-filament trailer light to operate as tail and brake lights, safety flashers, and individual turn signal indicators.

The converter circuit, shown in the schematic diagram, consists of two 10-watt resistors and two 25-volt, 5-ampere silicon diodes. These few components can be housed in a 1" x 2" x 2" metal utility box, which can then be bolted in any convenient location near the trailer lights. Connections to and from the converter circuit should be through a cable type trailer light.

The cables from your car brake and tail lights and to the trailer lights should be #18 or heavier wire. Use splice lugs on the ends of the wires that connect to the trailer block.

Once installed between the car and trailer lights, the converter operates as follows: with the car lights turned on, current flows through the tail light lead and both pairs of resistors and diodes to the trailer lights. The brilliance of the trailer lights is somewhat subdued as a result of the voltage drops across the resistors.

Now, when the car brake is operated, current flow bypasses the resistors and diodes, going directly to the trailer lights via the left and right brake light leads. Note, full current is delivered, and the trailer lights operate at full brilliance. The diodes are in reverse bias, preventing current from circulating through the diode resistor circuit.

When the directional signal or four-way safety lights are operated, the trailer lights again glow at full brilliance. Each lamp can operate singly since the diodes again restrict the current flow in one direction.

You will notice from the schematic diagram that only one connection is shown to each of the trailer lights from the car. The diagram assumes that the trailer and car grounds are coupled together to complete the circuit.

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ELECTRONICS, INC

"I'll say one thing for Charles—He's no problem on birthdays and Christmas."
TEST YOUR KNOWLEDGE OF SEMICONDUCTORS

BY WILLIAM R. SHIPPEE

1. Transistor Hfe remains steady regardless of temperature.
   (a) True  (b) False
2. Which of these elements used to dope semiconductor materials is an acceptor or a type?
   (a) Phosphorous  (b) Arsenic  (c) Antimony  (d) Indium
3. In a class A output stage, dissipation is always highest when there is no ac power output.
   (a) True  (b) False
4. Mesa and planar epitaxial transistors give high-speed switching and good saturation characteristics at relatively high voltage ratings.
   (a) True  (b) False
5. The configuration used most often for a transistor switching circuit is:
   (a) Common collector  (b) Common base  (c) Common emitter
6. Many mesa and planar transistors exhibit negative resistance after breakdown voltage is reached.
   (a) True  (b) False
7. Voltage feedback from the collector of a transistor stage tends to increase the output impedance of that stage.
   (a) True  (b) False
8. Below (top) is schematic symbol for:
   (a) Unijunction  (b) SCR
   (c) Tetrode  (d) npn transistor
9. Below (left) is schematic symbol for:
   (a) PNP  (b) SCR
   (c) JFET  (d) npn transistor
10. Below (right) is schematic symbol for:
    (a) Symmetrical JFET  (b) SCS
    (c) Npn transistor  (d) SCR

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