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Popular Electronics

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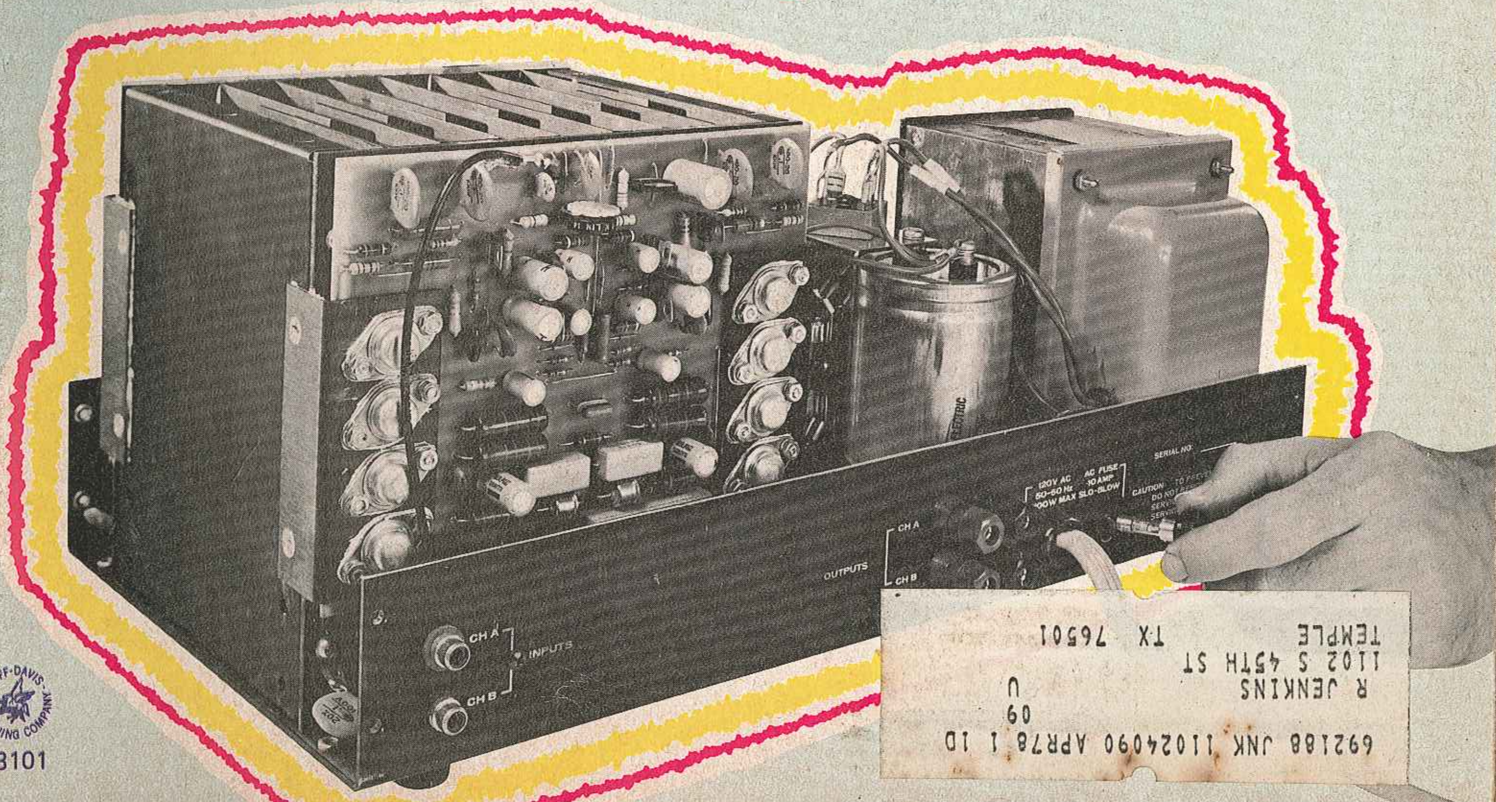

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Anatomy of a Stereo Phono Cartridge

BY JULIAN HIRSCH
Hirsch-Houck Labs

ALMOST every stereo system today has a turntable that is equipped with a stereo cartridge for playing disc recordings. The stereo phono cartridge itself is a miniaturized pair of electric generators that are coupled to a single-jewel stylus. The stylus follows the undulations of the V-shaped record groove. Each of the groove walls, containing one of the two stereo program channels, moves the stylus independently to produce an electrical voltage at the appropriate output of the phono cartridge.

The two basic types of modern phono cartridges are amplitude-responding and the velocity-responding. The amplitude-responding variety's output voltage is proportional to the magnitude of the stylus motion, while the velocity-responding cartridge generates a voltage that is proportional to its velocity, which is the product of amplitude and frequency. Examples of amplitude-responding cartridges include piezoelectric (crystal and ceramic), strain-gauge, and photoelectric designs. Magnetic cartridges, used almost exclusively in modern high-fidelity sound systems, are velocity-responding types.

The magnetic cartridge operates by varying the strength of a magnetic field surrounding a coil of wire or by varying the position of a small wire coil in a fixed magnetic field. Both designs are capable of generating a voltage in a coil. Magnetic cartridges are known by various names, including moving-iron, moving-magnet, induced-magnet, variable-reluctance, and moving-coil, depending on the specific design employed in their manufacture. No matter what the name, each cartridge type offers certain advantages and disadvantages, and all are capable of equivalent performance.

The output of a magnetic cartridge, being proportional to frequency, requires equalization to produce a flat frequency response. The output of the cartridge is very low, generally only a few millivolts. Hence, the required amplification and equalization to produce a usable signal for the sound system must be supplied by the phono-preamplifier section of the system's amplifier or receiver.

The mechanical design of the moving elements in the phono cartridge is usually more important than the method of transduction—a demand not always appreciated by the user. The stylus must be able to reverse its direction thousands of times each second in exactly tracking the complex modulation on the groove walls; yet, it must not damage or permanently alter the shape of the groove modulation pattern.

Diamond, which can be shaped and polished with great accuracy, is universally used for high-quality playback styli. The tiny jewel (which may be difficult to see with the naked eye) is mounted with a precise orientation at one end of a light, hollow metal tube that is pivoted near the other end. The deflection of the tube by the motion of the stylus moves a portion of the magnetic circuit to generate the output voltage.

The dynamic contact force between the stylus and the groove, which determines the amount of tracking force needed, depends on several factors. Among these are the mass of the moving elements that must be accelerated during the rapid direction changes and the compliance (the inverse of stiffness) of the stylus cantilever system. Designed to track at forces as low as 1 gram, the best modern phono cartridges often have an effective stylus mass of less than 1 milligram and a compliance of 35×10^{-6} centimeters/dyne or more. Such cartridges are relatively delicate and should be used only in properly designed tonearms. Cartridges designed for low- and medium-priced record players have sturdier and less compliant stylus assembly systems that are meant to operate at forces of 2 to 3 grams. Although there is sometimes surprisingly little difference in sound quality between a 3-gram cartridge and one rated for 1-gram operation, the latter can be expected to produce somewhat less record wear over a long period of time. Cartridges requiring a force of 4 grams or more should not be used for serious high-fidelity listening applications.

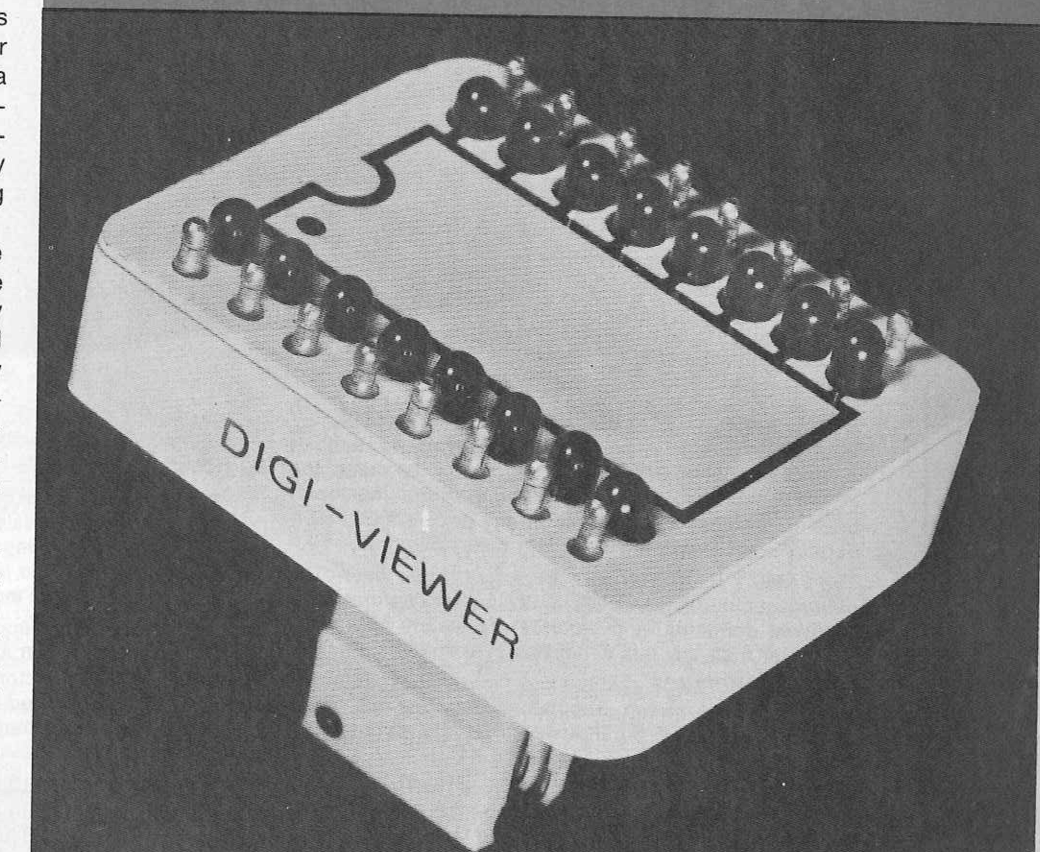
Although stylus mass and compliance ratings of cartridges are sometimes published, they are of limited usefulness in judging cartridge quality since many other unspecified factors are involved. In the absence of other information, the manufacturer's rated range of tracking forces is a good indication of overall cartridge performance (a lower force implying a generally superior product), although not necessarily of its listening quality compared to other cartridges.

The tracking ability of a cartridge refers to its ability to faithfully reproduce high recorded velocities (levels) over a wide frequency range at a given tracking force. Exceeding the tracking ability of a cartridge causes an unmistakable harsh, shattering sound. Sometimes, but not always, increasing tracking force will help. Almost all cartridges operate best when used near the high end of the recommended tracking force range. Few manufacturers provide specific information on tracking ability, but test reports such as those in this magazine serve as a useful guide.

The shape of the tip of the stylus jewel, which is the only part of the cartridge to actually contact the record, is an important factor in performance. The standard stylus has a spherical tip with a radius of 0.0007 in. (0.7 mil). More accurate tracking of very short recorded wavelengths (the higher frequencies, especially near the center of the record) is possible with a small tip radius, such as 0.5 mil. However, this causes a higher pressure per unit of area on the vinyl record, which can increase record wear unless a very low tracking force is used. A 0.5-mil stylus is not well suited to playing monophonic LP records.

An excellent compromise in stylus design, now widely used, is the elliptical stylus. Across the record groove, it has a radius of 0.7 to 0.9 mil, but along the length of the groove the radius is only 0.2 to 0.4 mil. The elliptical design yields superior high-frequency performance without excessive record wear as well as improved quality on mono discs. However, the most common elliptical size of 0.2×0.7 mil should not be used at forces exceeding 2 grams, which limits its use to the higher-priced phono cartridges. ◈

BUILD DIGIVIEWER II



Simultaneously checks up to 16 pins of any digital IC

BY DON LANCASTER

SOONER or later if you are working with digital IC's you're going to have to check the states of the signals at the various pins. You can view the waveforms on a scope, check the voltages with a meter, or use a standard logic probe. With either of these procedures, however, you can only check one pin at a time.

Now, with the Digiviewer II (costing less than $19), you can simultaneously check all 14 or 16 pins of an in-circuit DIP package. The IC can be CMOS, TTL, DTL, RTL or other positive-supply digital logic. All you do is "glomp" the Digiviewer on the IC and LED readouts will indicate the state (0 or 1) at each pin. Masks can be inserted in the face of the Digiviewer to show the internal arrangement of common IC's so that there is no need to refer to a data book.

The Digiviewer also allows a solderless, snap-on connection to IC pins for measurements, monitoring, or "force-feeding" functions such as a reset. The glomper clip has gold-plated contacts that cannot short between pins, and a sliding clamp firmly locks the Digiviewer to the IC being tested.

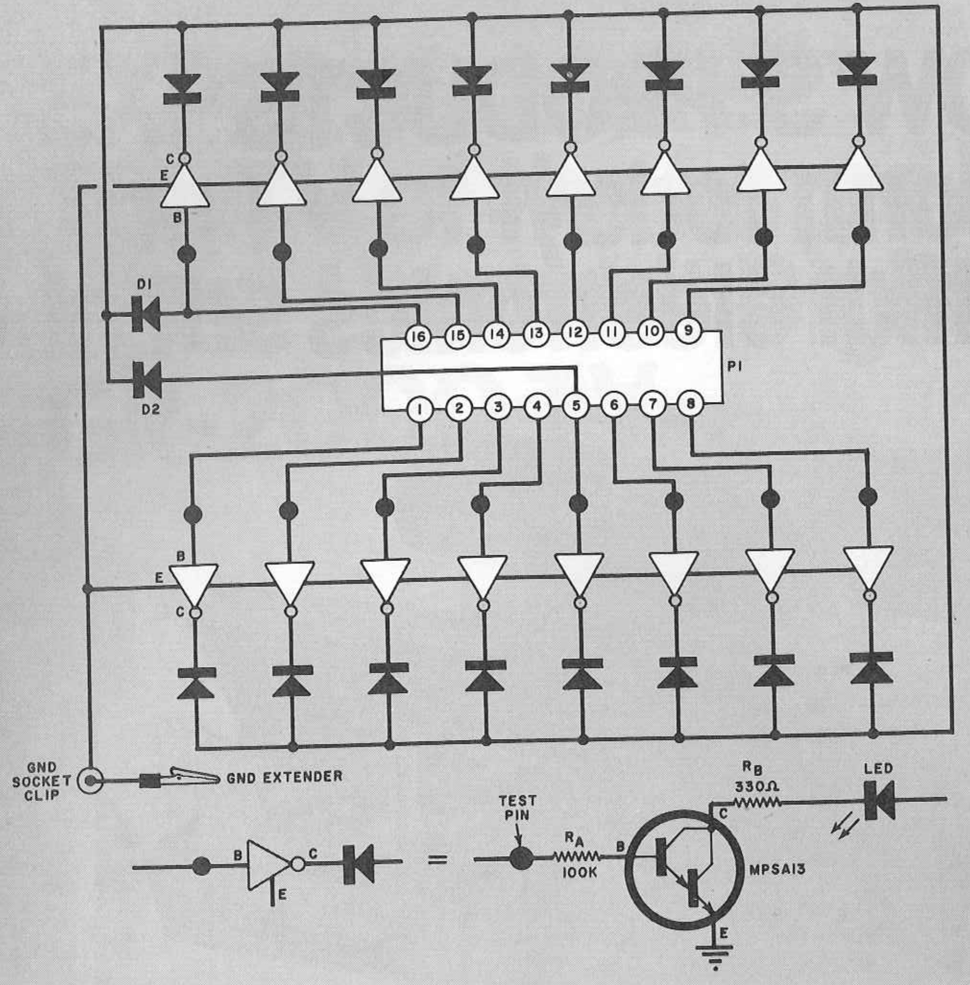
The fixture locates the positive power supply automatically and the ground point is obtained either by plugging the Digiviewer's ground lead into the proper test pin or by using a ground extender to the system ground. The top half of the Digiviewer can be used alone as a permanent 16-place state monitor to be built into any circuit.

The logic decision point of the Digiviewer is 1.3 volts. Input signals above this level cause the associated LED's to light. Signals below 1.3 V indicate a logic 0, a ground, no connection, or an unterminated tri-state or open collector output.

While the Digiviewer works best on a visual rate with static clockings of the digital circuit, at higher speeds, the duty cycle of a particular pin will show up as a variable brightness. For instance, the Q and $\bar{Q}$ pins of a binary dividing flip-flop will cause the LED to glow at half brightness.

The input impedance of the Digiviewer is 100,000 ohms at 1.2 volts and it will operate over any supply voltage from +4 to +10 volts. For higher supplies, voltage-dropping resistors can be used.

Circuit Operation. As shown in Fig. 1, each of the 16 pins of the glomper



PARTS LIST

D1, D2 — 1-ampere silicon rectifier diode
LED1-LED16 — 0.2-in. diameter LED
P1 — Glomper clip (Guest International)
Q1-Q16 — MPSA13 or MPSA14 npn Darlington transistor (minimum gain 5000, do not substitute)
R_A(16) — 100,000-ohm, ¼-watt resistor
R_B(16) — 330-ohm, ¼-watt resistor
Misc. — Test pins (Molex 0.093" diameter by 0.6" high, 17 required); heavy wire for board interconnections; flexible insulated wire; test socket (Molex 02-09-1118); heat-shrinkable tubing; insulated alligator clip; etc.
Note: The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: etched and drilled pc boards at $3.25; complete kit of parts (#VU-2) at $19.50; mask sets (specify RTL, 7400TTL, 4000CMOS, or blank) at $2.50.

Fig. 1. Circuit consists of 17 identical high-input-resistance Darlington LED drivers. Power is derived from pin 5 or pins 14/16, common positive pins.

clip (*P1*) is connected to a Darlington transistor npn amplifier through a 100,000-ohm resistor. The output of each transistor goes through a current-limiting resistor and then through an LED indicator to the positive line. All 16 emitters are connected to the common ground. Diodes *D1* and *D2* are connected to pin 5 and pins 14/16 to handle the positive power supply. On a 14-pin DIP IC, pin 16 becomes pin 14 and the two right-hand LED's should be ignored. Only the most positive pin contributes to the Digiviewer power; the other diode is back biased and does not load the input. To test an IC that does not have pin 5 or pin 14/16 as the supply, another diode is needed (or 14 more diodes can be added—one for each pin).

Construction. Two printed circuit boards, stacked, are recommended for the Digiviewer. One is used to hold the glomper clip and the rest of the electronics is mounted on the second.

Assemble the top board (Fig. 2A and B) first. Attach the resistors first. In mounting the transistors, arrange their leads so that the transistor bodies are as close as possible to the pc board. The emitter terminal of each transistor goes on the inside, so half of the transistor "flats" point one way and the other half the other way. This insures that all the emitter terminals are connected to the common grounds. Attach the diodes last.

Now temporarily insert and solder tack a test pin in each of the four corners. These pins and a flat surface are used to set the height of the LED's, which are uniformly spaced 0.2 in. off the pc board.

Note that an LED has a critical polarity. The cathode or resistor end has a slight flat on the plastic base. If the leads are of different lengths, the longer lead is usually the anode. One LED at a time is slipped into place and the pc board is then turned upside down (on the flat surface) to stand on the four corner test pins. Each LED pin is brought out vertically and tacked in place. Be sure the tops of the LED's just touch the flat surface and that the units are vertical.

The remainder of the test pins are then inserted on the same side as the LED's. Make sure that the pins are vertical and firmly seated before soldering them in place. Be careful not to let solder flow into the small hole at the bottom of each pin.

Complete assembly of the top board by adding an insulated (black) flexible ground lead, feeding it through a hole drilled above *D2*.

To test the board, use a 5-volt dc power supply and connect the loose end of the ground lead to the power supply negative. Connect the positive supply (5 volts) to the 14/16 test pin and note that the associated LED comes on. Make a connection between pin 5 (+5 volts) and each of the other pins and note that each associated LED comes on. To make a threshold check, leave the 5-volt supply on and use another, variable dc supply to check each input. The LED's should be off at about 1.1 V and fully lit at 1.5 V.

The foil pattern for the lower pc is shown in Fig. 2C. The outside dimensions of this board should be exactly the same as those of the upper board. Note that there is a slot in the board spanning pins 1 through 8.

Pins 9 through 16 of the glomper clip mount in the indicated holes, with the glomper on the nonfoil side of the board. (In the finished project, the foil sides of the board are facing each other.) Pins 1 through 8 of the clip pass through the slot in the board so that the arm of the clip can swing through a slight arc when the clip is mounted on an IC. The arm of the clip is the thinner side.

Each of the arm pins is connected to the pc foil through a short length of very flexible, thin, insulated wire. Be sure that these leads do not get covered with solder which will make them stiff. Be sure the clip arm moves freely.

The two pc boards are attached as shown in Fig. 3, with a spacing of ¼ in. Make up 16 short, heavy wire stubs just thick enough to slip through the holes in the bottom board. Insert the stubs in the holes and solder them in place on the foil side. Allow a small stub on the nonfoil side so that optional contact can be made to each pin.

Fit the boards together, soldering each stub into the hole of its associated test pin. Be sure not to loosen the test pin as you solder. Pass the insulated ground wire through the hole in the lower board and cut it so that it is about 6 or 8 inches long. Solder a push-on connector to the end and cover it with a length of heat-shrinkable tubing. Make up an extension ground lead, using a mating push-in connector and heat-shrinkable tubing at one end and an insulated alligator clip at the other.

The snap-on cover is fabricated of thin-walled (preferably white) plastic sheet. It can be made in two pieces (the top and a skirt) which are then cemented together after all drilling is complete.

The upper surface is 2¹⁄₁₆ in. by 2⁷⁄₁₆ in., which is just large enough to fit over the LED's and test pins, with a little to spare. Sixteen ³⁄₁₆ in. holes should be drilled to mate with the LED's. Also drill 16 ⅛-in. holes to mate with the test pins. The outline of a 16-pin DIP should be drawn on the upper surface with a notch and dot code used to identify pin 1. The skirt, about ⅝" deep, is cemented to the upper cover. When the assembly is complete, the snap-on cover should seat firmly over the pc board assembly.

Use. Make up a series of masks for the most commonly used DIP IC's. Use indelible pencil or ink to draw the logic of the IC and identify the positive and ground pins. The masks should be held snugly against the LED's.

In fitting the glomper clip over an IC, be sure that pin 1 of the clip is on pin 1 of the IC. Connect the floating ground test lead to the circuit ground, or to the ground pin of the Digiviewer. Note that the supply voltage is present at the correct pin as indicated by an illuminated LED at that position.◈

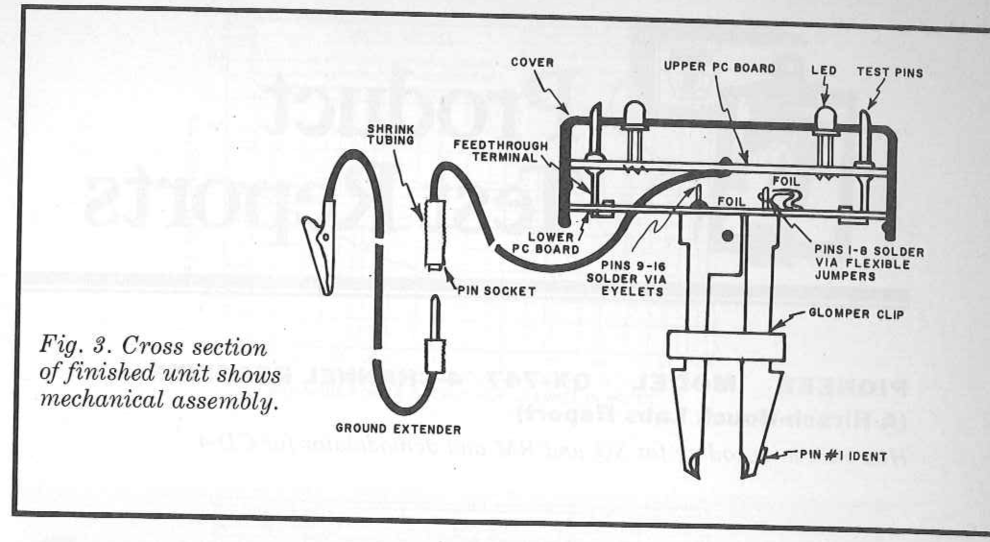


Fig. 3. Cross section of finished unit shows mechanical assembly.

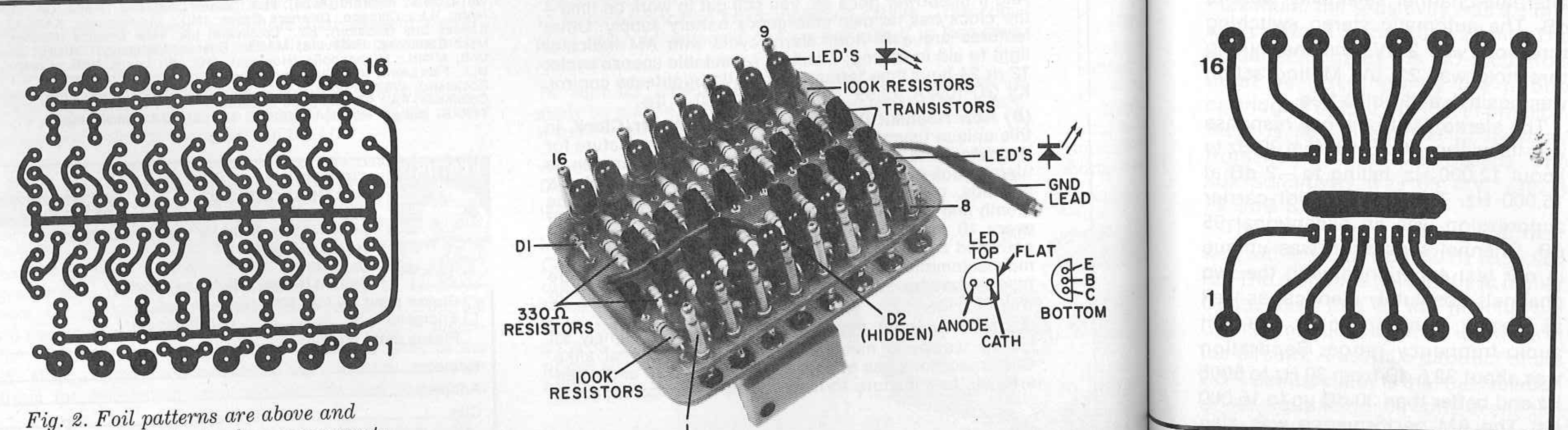


Fig. 2. Foil patterns are above and right. Photo callouts show components.