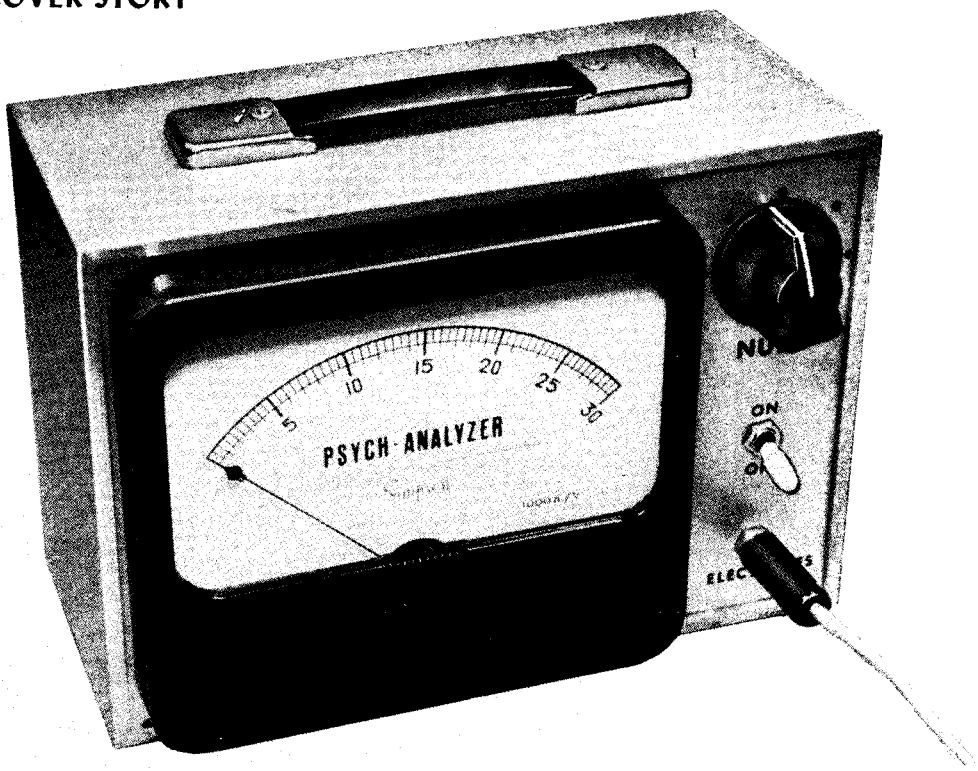
COVER STORY



Build a PSYCH-ANALYZER

CHECK EMOTIONS AND SENSIBILITIES BY GALVANIC SKIN RESISTANCE

BY ROBERT E. DEVINE

AFTER SEEING the latest adventures of your favorite TV detective, have you ever wished you had a lie detector of your own? You could check your friends' psyches—determine their likes, dislikes, phobias, and idiosyncrasies! You can do it with the "Psych-Analyzer" —a device that's easy to construct and will provide you and your friends with many entertaining (and maybe revealing) hours.

The term "lie detector" is actually a misnomer. The Psych-Analyzer can only detect and display variations in the electrical resistance of the subject's skin. Such variations are directly related to physiological fluctuations caused by emotional stress and are beyond the control of the subject; hence, psychologists call them "autonomous." It is the examiner's job to observe and interpret the responses. Detecting a lie requires skill in the interpretation.

The professional lie detector (best known in the Keeler polygraph) simultaneously measures and records several parameters of physiological response that are known to fluctuate under emotional stress. These include blood pressure, depth and rate of breathing, pulse rate, and skin resistance. Of these, the most easily observed and the most dramatic in its dependability is the skin resistance in the palm of the hand. It is this meandering value of resistance that the Psych-Analyzer detects and displays —the significance is complex. Only a professional psychologist could determine

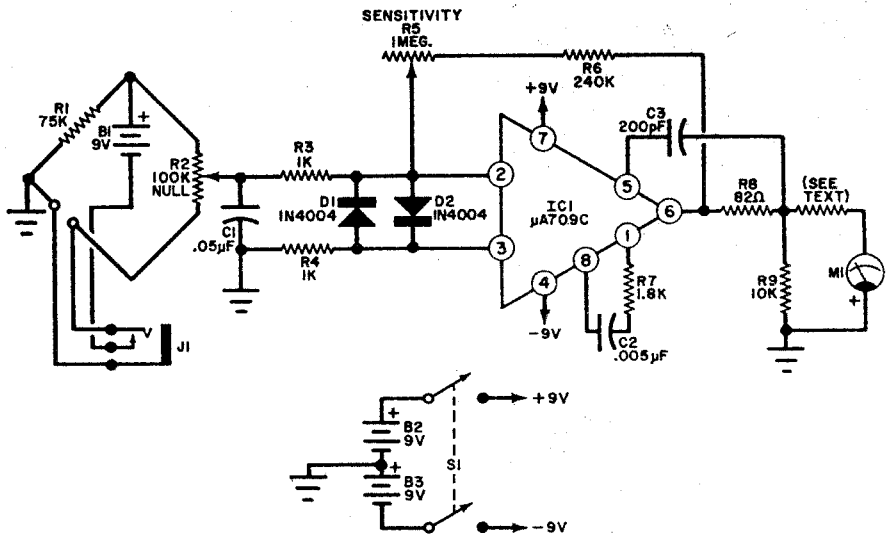


Fig. 1. The low-level d.c. error signal generated in the bridge is amplified by the high-gain IC amplifier and displayed on the meter.

PARTS LIST

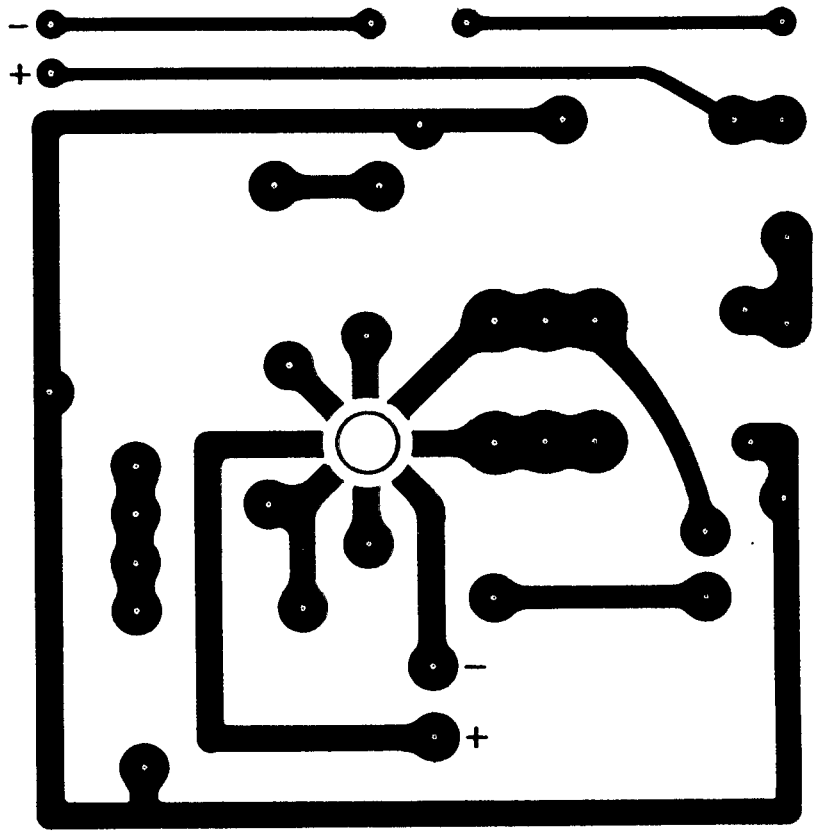
B1-B3—9-volt battery
C1—0.05-μF capacitor
C2—0.005-μF capacitor
C3—200-pF capacitor
D1,D2—1N4004 (or any silicon diode)
IC1—Integrated circuit (Fairchild μA709C). See text.
J1—Modified closed-circuit jack. See text.
M1—0-1-mA meter with series resistor (2500 to 3000 ohms) to measure 3 volts.
R1—75,000-ohm, ½-watt resistor
R2—100,000-ohm potentiometer
R3,R4—1000-ohm, ½-watt resistor
R5—1-megohm potentiometer (miniature preferred)
R6—240,000-ohm, ½-watt resistor
R7—1800-ohm, ½-watt resistor
R8—82-ohm, ½-watt resistor
R9—10,000-ohm, ½-watt resistor
S1—D.p.s.t. switch
Misc.—Eight-pin TO-5 socket (for IC1), two 1"-square pieces of heavy copper or two large foreign coins, pair of bicycle clips, length of insulated wire, battery clips (3), case as desired, mounting hardware, etc.

the true meaning—in the meantime, have some fun!

Construction. The complete schematic of the Psych-Analyzer is shown in Fig. 1. Since it is basically a d.c. amplifier and problems due to lead length or placement are not likely to occur, the project lends itself to breadboard-type construction. Interfering high frequencies, caused by r.f. pickup, are bypassed to ground at the output of the bridge. Before final packaging, a conventional VOM, VTVM, or TVM switched to its 2.5- or 3-volt range can be used to test the circuit instead of the regular output meter.

To insure a neat finished product, however, and to avoid inadvertent wiring errors, it is preferable to use an etched circuit board (shown actual size in Fig. 2). Once the board is complete, all components except *IC1* can be installed as shown in Fig. 3. The IC is mounted in an 8-pin, TO-5 socket that fits into the hole drilled in the circuit board. Notch out a small indentation in the board for the socket locating projection, noting that this projection is at pin 8 of the IC. The tab on the IC is also located at pin 8. Push-fit the IC socket into the hole and solder the leads to the adjacent solder pads of the foil. When soldering the components, take care not to use excessive heat as this can damage diodes *D1* and *D2*.

Before installing *IC1* in its socket, its leads should be trimmed down to approximately ¼" in length. Do not use a conventional side cutter for this purpose since the cutting force of typical side cutters can damage the IC. Common wire strippers, hinged like a pair of scissors



USE
741 OP-AMP

Fig. 2. Actual-size printed board foil layout. You can create this circuit on perf board if desired.

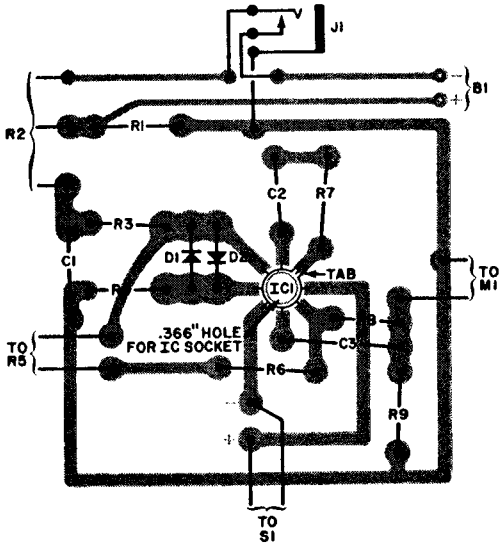


Fig. 3. Install the components as shown here. Note that J1 is arranged to close when plug is inserted.

and having a relatively gentle cutting action, should be used.

A jack, for *J1*, that has one contact that closes when the mating plug is inserted may be difficult to find. You can use a jack that has a normally closed circuit and modify it so that it fits the circuit as shown in Fig. 1. Just be sure before you buy the jack that it is a type that can be modified (by bending the top contact so that it is on the bottom).

Any type of d.c. voltmeter capable of indicating to 2.5 or 3 volts can be used for *M1*. If you use a 1-mA ammeter, insert a 2500-3000-ohm resistor in series with the meter to convert it to a suitable voltmeter.

At the time of the writing of this article, the price of the μA709C varied from $4.10 (Fairchild Semiconductor) to $9.75 (ITT). The suffix "C" signifies a low-cost commercial unit and should be used when ordering. Without a "C" the 709 is a military IC and may cost $15 or more. This IC is also made as a dual,

in-line, or flatpack unit, so be sure you get it in the TO-5 package.

Any type of case can be used to house the analyzer. Mount meter *M1*, NULL control *R2*, power switch *S1*, and jack *J1* on the front panel. Although the author mounted SENSITIVITY control *R5* on the back panel, it also can be mounted on the front if desired. Control *R5* should be marked LO when its rotor is away from *R6*, HI with its rotor adjacent to *R6*, and MED in the middle.

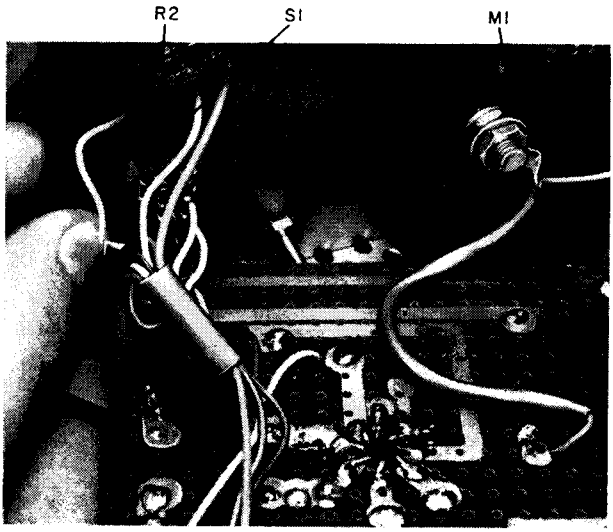
The batteries can be mounted on one wall of the chassis, using strips of aluminum to secure them in place. Mount the PC board using standoffs.

Electrodes. The electrodes are made from pieces of 1"-square, ⅛"-thick copper slightly rounded with a ball-peen hammer so that they are convex to fit the palm of the hand. You can also use two large foreign coins (such as Mexican 20-centavo pieces). Although copper is preferred for the electrodes, the large coins will work. (Note that the electrodes must be kept clean during use. Polish them occasionally with a piece of fine sandpaper, especially if the copper or other metal gets to be dark or oxidized.

Solder a small U-shaped bracket to the concave side of the electrode to hold one end of the clamp. The clamps hold the electrodes snugly in the palms of the hand and are made from a pair of bicycle pants clips, available at bike supply shops. The spring tempering at one end of each clip must be removed through heat treatment. Using any form of heat (gas stove, blowtorch, etc.) heat one end (for an inch or less) of each clip until it is cherry red, then allow it to cool slowly. After it has cooled, insert this end under the U-shaped bracket allowing about ¼" to protrude. Make a sharp bend on this small tip so that the clip cannot come out of the bracket. When this is done, the electrode should be able to pivot freely on the end of the clip and position itself automatically in the palm of the hand. The remainder of each clip can be bent so that the electrodes fit snugly in the hands. For comfort and to insulate the back of the hand, cover the clips with cambric tubing.

To connect the electrodes to the detector, use a 2-to-4-ft. piece of two-wire cable and separate the two leads at one end for about 1 foot. Solder one wire to each electrode and put a male plug on the other end to mate with *J1*. No wiring polarity need be observed. At the electrode end, secure the wire to the cambric-covered clip to prevent its being accidentally torn loose from the electrode.

Testing. Even if power switch *S1* is in the ON position, the amplifier section does not have an output if the bridge circuit is not energized. This is done by inserting the electrode plug into *J1*. Never leave the electrodes plugged in even if *S1* is turned off, since the bridge circuit power is automatically applied whenever the plug is inserted. To shut off the de-



Lengths of insulated tubing can be used to create neat-looking cabling between the PC board and front-panel components. Use wires of different colors for each lead to facilitate signal tracing.

tector completely, place *S1* in the OFF position and remove the electrode plug.

To check system performance, temporarily clip a fixed resistor of 50,000 or 100,000 ohms between the electrodes. Insert the electrode plug in *J1*. Place the SENSITIVITY control on LO and the NULL control near its mid-scale position. When you turn *S1* on, rotating *R2* should cause the meter needle to swing smoothly from zero to full scale. A 75,000-ohm resistor will cause the meter to indicate zero with the NULL control near its center of travel.

If the system works all right so far, pinch both sides of the temporary resistor with the thumb and forefinger of each hand. This reduces the effective resistance and should make the meter indicate up scale. If the indication is down scale, check the polarity of the meter connections or the battery connections to the bridge circuit.

Rotating *R5* to MED or HI increases the sensitivity proportionately. In actual practice, it is seldom necessary to use high sensitivity unless the subject has extremely high skin resistance or abnormally low emotional activity.

Unplug the electrodes and turn *S1* off. Always do this if the detector is to be left off for any period of time.

Using the Psych-Analyzer. To protect the meter from unnecessary overload, before using the analyzer, set the NULL control (*R2*) near its center of rotation, set the SENSITIVITY control at MED, and place the electrodes on the subject's palms.

With the subject seated comfortably, an electrode on each palm, insert the plug into jack *J1* and turn on the power switch. Bring the meter needle to a point just above zero by use of the NULL control. Hereafter, aside from "noise" due to a change in the pressure of the electrodes against the subject's skin or any slight motion of the subject's muscles, all meter movements represent bona fide changes in skin resistance. From time to time you will have to re-zero the meter as the absolute level of skin resistance changes slightly. Generally speaking, the absolute level represents the subject's state of arousal.

There are innumerable stimuli that will cause a subject to react and start an internal chain reaction beyond his control. The end result is an upward swing of the meter signifying a decrease in skin resistance. The stimulus can be conveyed through touch or sound or any of the other senses, but the most dramatic reaction—particularly for aural stimuli—will result from a stimulus that has strong emotional attachments (the names of loved ones, for instance) or that is distasteful (taboo words).

The *expectation* of stimulus can also cause an indication on the analyzer. For instance, clang two pieces of metal together, and the subject will almost invariably exhibit a large response. After things have returned to normal (30 to 60 seconds) pretend to make the same noise again but stop just short of doing so. The response will be almost as great as before.

A point of interest is the latency or delay between the occurrence of a stimulus and the meter response. One authority in the field claims that the latency is 1.7 seconds for an aural stimulus and 2.1 seconds for a visual stimulus. If you have a stopwatch, you can check this.

Another authority has a theory about

HOW IT WORKS—ELECTRONICALLY

The circuit of the Psych-Analyzer is divided into three sections: a measurement bridge, a d.c. amplifier, and an output indicator.

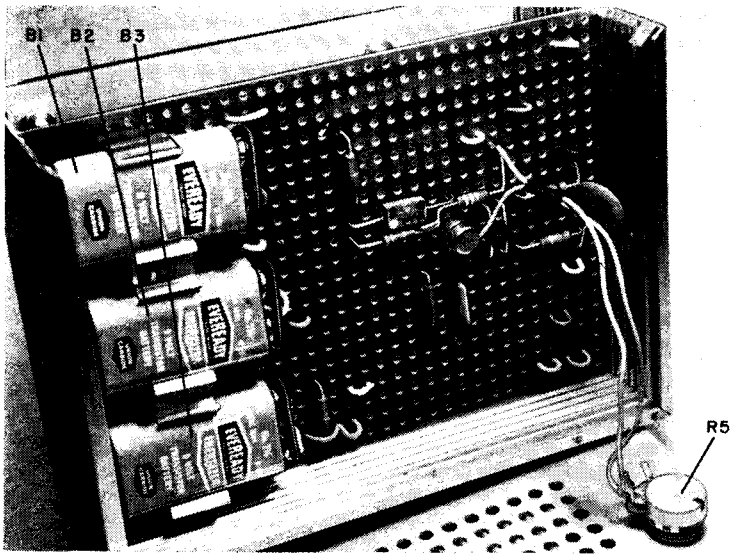
The bridge is made up of *R1*, *R2*, and the subject's skin resistance. Resistor *R1* corresponds to the known resistor of a Wheatstone bridge, while the skin resistance is the unknown. The output voltage of the bridge is nulled by rotation of *R2* to balance the bridge. If, after the bridge is balanced, the resistance of the subject's skin varies, the bridge is unbalanced, and a d.c. voltage appears on the arm of *R2*. This low-level d.c. signal is amplified by the operational amplifier *IC1*. Capacitor *C1* is used to bypass unwanted a.c. signals that may be induced into the circuit from stray power-line pickup or r.f. from nearby radio stations.

To protect the IC from excessive input, series resistors *R3* and *R4* limit the current flow and diodes *D1* and *D2* reduce transients by limiting the input level to 0.6 volts. (Incidentally, there are 15 transistors in the *IC1*, TO-5-size case.)

The operational amplifier is used to perform certain mathematical operations in computer applications. The amplifier gain can be controlled by varying the amount of feedback from output to input (pin 6 to pin 2). This is done by varying the setting of *R5*.

The resistor-capacitor circuit (*C2-R7*) between pins 1 and 8 and capacitor *C3* between the output and pin 5 are used for frequency compensation. Resistor *R8* protects the IC against overload damage if the output is accidentally shortened.

The voltmeter has a 1000-ohm-per-volt movement with a 0-to-3-volt scale.



The three 9-volt batteries are supported by clips at one end of the oversize perf board. Although the author mounted R5 (sensitivity control) on rear, it could just as well be mounted on the front panel.

HOW IT WORKS—PHYSIOLOGICALLY

In 1888, a scientist named Féré found that if he attached an electrode to each forearm of a human subject and connected these electrodes in series with a weak source of d.c. and a galvanometer, the galvanometer needle would have rapid, upscale deflections when the subject was emotionally stimulated. The phenomenon is still sometimes referred to as the Féré effect, but is now more commonly called GSR, galvanic skin response (or resistance). Most electronics experimenters have noted this effect when they hold the leads of an ohmmeter in their hands.

Tests have shown that the GSR effect is actually strongest in the palms of the hands and soles of the feet, the back of the hand and wrist being less responsive. In 1929, another scientist (Richter) noted that the GSR effect disappears when the electrodes pierce the skin.

It would be natural to assume that the GSR effect is a function of the amount of perspiration on the skin, a common indication of emotional stress. Although this might play a small part, it is not the whole answer. Experiments have shown that, if two small pieces of toweling are soaked in warm salt water (to simulate heavy perspiration) and placed between the skin and the electrode, the GSR effect does not disappear.

Since there is still no absolute explanation of the GSR effect, feel free to form your own opinion.

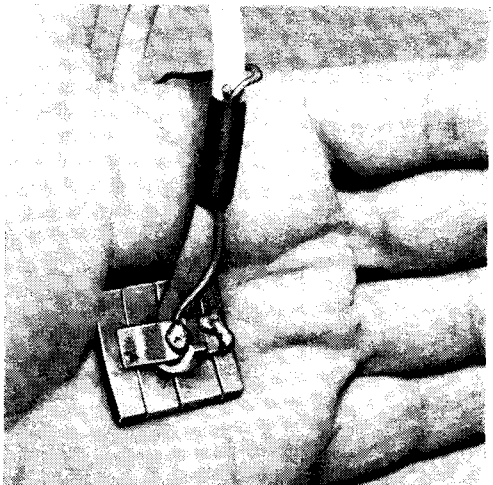
latency when taboo words are used. By mixing pleasing words with unpleasant ones he discovered that the latency was much greater with the unpleasant ones. He attributes this to "fear of punishment." Although his subjects were college students, he felt that they unconsciously put up a defense (inbred from childhood) against these forbidden words and therefore took longer to recognize them. You will also find that a subject's response declines with repeated stimuli of the same nature—a matter of adaptation on his part. A period of rest will restore the subject to his previous state of reaction.

As mentioned previously, the absolute level of skin resistance at any particular time represents a measure of general activation or arousal. This is sometimes referred to as Base Line Conductance. (Conductance is the inverse of resistance.) The base is high (high conductance and low resistance) when the subject is wide awake and alert and low when he is drowsy or asleep.

An easy way to determine the validity of the Psych-Analyzer as a lie detector

(*Continued on page* 116)

Each electrode should fit snugly in the palm of the hand. The modified bicycle-clip clamp should be insulated with tubing to provide electrical isolation.



PSYCH-ANALYZER

(*Continued from page 32*)

is through the use of playing cards. Show a subject five playing cards and ask him to select mentally one of them. Instruct him to say, loudly and with real conviction, "No! That is NOT my card!" every time you show him one of the cards and ask, "Is *this* your card?" Four times he will be telling the truth, the other he will be lying. Don't let the subject watch the meter, but keep your eyes on it all the time.

Sometimes the subject will show a marked response to two cards, and you will have to work a bit longer to discover which of the two he picked. Female subjects are sometimes so responsive that you can perform this test without words, merely showing the cards to the subject. Just the sight of the card causes the meter to jump.

Experience has shown that long-time poker players sometimes respond to an ace or a joker even though it is not the card chosen. Likewise, players experienced in the game of Hearts will react to the sight of the queen of spades without having chosen it. The experiment will be easier, therefore, if you leave out cards with specific connotations.

The Psych-Analyzer should be a natural for parties. It has great possibilities as a "passion meter"—if you keep things under control! You might discover that some person who is very blasé on the surface is actually a bit prudish underneath. You might find out who sent you that unsigned Valentine card that was supposed to be funny but didn't strike you that way. Or you might try a game where someone commits a "crime" while the lights are out. Then you try to find the guilty party. *However,* don't "hang" anyone just on the basis of the skin resistivity of his palms.

As a quick check of whether or not your Psych-Analyzer is functioning, connect it to a subject's palms—or even to your own—and have him take a deep breath. The meter should give a definite indication after the relaxation of the deep breath has passed and the air has been exhaled. There may be some latency in this indication also. -30-