biofeedback — instant yoga?

Using electronic biofeedback techniques you can monitor the internal operation of your body. But that's not all - knowing what's going on enables you to control usefully some of the processes, helping you to relieve tension and the disorders resulting from it. Collyn Rivers explains.

AN ESSENTIAL PART OF MOST control processes is some form of feedback information which enables the system to maintain a controlled equilibrium.

A room thermostat, for example, senses room temperature and regulates heat output accordingly — an indication of the heater's operation is 'fed back' to enable temperature to be automatically controlled.

When you learn the piano you see or sense where the keys are, and how hard you are striking them. The piano makes corresponding sounds which are fed back to your ear. Your brain now compares what you've got with what you hoped you had. This process of feeding back information about what you are achieving so you can compare it with what you are *trying* to achieve enables you to make appropriate corrections. In this example the acoustic feedback is vital.

A similar process is involved when you learn to ride a bicycle — the feedback process is so effective that balancing eventually becomes automatic.

Feedback is used when you first drive a strange car. The first time you brake you know only within wide limits the relationship between pedal pressure and deceleration. It may be as low as 5 kg or as high as 25 kg for (say) 0.4 G. But the very first time you press that pedal several feedback loops come into operation. Your stomach is sensitive to rate of change of velocity and it sends signals to your brain — your eyes sense the rate of change also — this data too is sent to your brain. If the tyres are squealing then there's an acoustic loop as well.

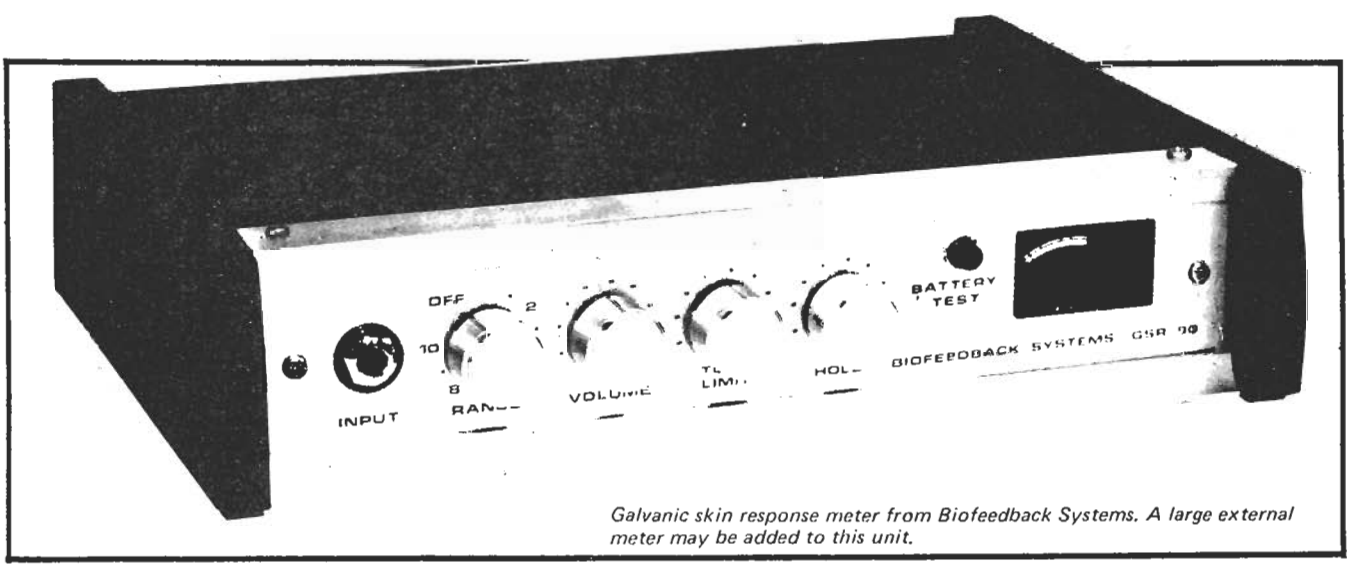
These and innumerable other physiological mechanisms collectively tell you whether you're pressing that pedal too hard or not hard enough, and you make a series of appropriate corrections — virtually instantaneously. Once you've done this a few times the response becomes automatic. You've used feedback to learn, and subsequently reinforce, a new skill.

THE AUTOMATIC NERVOUS SYSTEM

So far we've described what are primarily external feedback loops. But the body has a vast number of internal automatic mechanisms — what medics call the autonomic nervous system. These are internal feedback loops and whilst they're working correctly all one normally perceives is the end result. If the body is too hot it perspires — if you run for a bus your respiratory rate increases, if you walk from a light area to a dark area your pupils expand accordingly. And all these mechanisms work in very much the same way as their technological equivalents.

Until recently it has been taken totally for granted that man had no control over the autonomic nervous system. We could learn to control at least some of our external bits — but not our internal systems. We knew we could learn to use our hands — or even wiggle our ears — but to control body temperature or heart rate was something else again.

And until very recently Western science believed this implicitly — despite ever-increasing evidence to the contrary. Yogis have long maintained that *they* have some measure of control over their autonomic systems, but the evidence was always anecdotal rather than scientific. (It is only in the last decade that their performances have been monitored and scientifically authenticated.)



Galvanic skin response meter from Biofeedback Systems. A large external meter may be added to this unit.

biofeedback —

Then ten or so years ago the scene suddenly changed. It was caused by a now classical experiment involving the study of part of the brain's electrical activity. Researchers were studying a subject's alpha rhythms (a low amplitude 10 Hz generated when the subject is relaxed). It was found that if the subject could *perceive* a signal corresponding to his alpha activity he could learn to generate more or less of it at will. Even more excitingly, it was found that almost all subjects could do the same.

CONTROLLING YOUR INSIDES

For the first time it was proved scientifically that humans could control some internal processes once a visual or aural feedback loop was established. Yet the tremendous significance of this discovery was not at first appreciated by the medical profession, but rather by engineers and physicists who were of course more familiar with the use of feedback in control systems.

Subsequent experiments have shown that a very large number of internal functions can be controlled in the same fashion — and even more importantly that many partially mal-functioning mechanisms can be 're-programmed' so that newly-learnt patterns can become automatic.

One of the most important of these is conscious control of tension and anxiety, for this implies that it is possible to control tension-related conditions such as migraine, colitis, asthma etc.

Other work has shown that it is possible to control hypertension (high blood pressure), heart rate, muscular tension, body temperature — and of course to generate, or at least partially control, alpha, beta and theta brainwaves. It is in fact now commonly believed that it may eventually be possible to bring under some degree of voluntary control *any* physiological process that can be continuously monitored, amplified and displayed

GALVANIC SKIN RESPONSE

The skin is an extraordinarily sensitive and rapid indicator of stress. Some people know this only too well — they literally develop nervous rashes.

When you become tense a number of readily measurable changes take place. A major change is the massive shift in electrical resistance of the dermis (the layer beneath the skin's outside surface). This shift is not only large but also very swift and the reaction happens regardless of where the centre of stress happens to be. A minor change in tension of a stomach muscle will cause just as large a change as clenching your fingers.

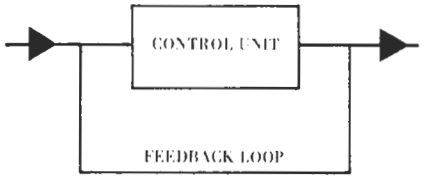
Galvanic skin response monitors (or GSR machines as they're generally called) monitor the resistance between two adjacent fingers of one hand. They translate and present this data as a meter indication or as a tone of related pitch (i.e. as tension decreases, pitch falls, and vice versa).

GSR machines are quite easy to build: they can be simply expanded-scale ohmeters covering the range 5000—100 000 ohms. A sensitivity control is essential, as is a readily adjustable method of switching resistance ranges.

Readout may be a simple analogue meter (digital tends to be harder to read in this application) or preferably a corresponding audio tone in which the pitch decreases as tension falls. Surprisingly perhaps GSR resistance *increases* as tension falls.

Electrodes may be made from any flexible conductive material — like steel wool, soft metal mesh etc — held firmly against the fleshy part of your finger tips by a velcro strap or something similar.

GSR machines are very easy to use. In fact one of the best ways is simply to switch on and try to cause the meter reading to fall — or the tone to drop in pitch. Usually you will find out how to do this within a few minutes.

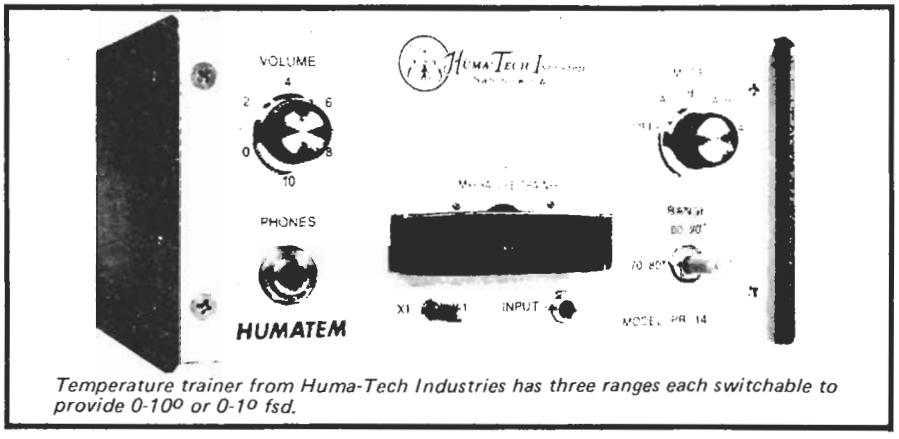


The basic feedback loop.

GSR machines make you ***aware*** **of** tension — and then enable **you to** *control* that tension. Eventually — after ten or so half-hour sessions the conscious control that you have learned becomes an automatic response. From then on the GSR machine is no longer required. In fact it becomes a handicap to further progress just like retaining 'training wheels' on a kid's bicycle.

Biofeedback thus operates in the opposite way to drugs. You can use sedatives to control tension if you wish. But if you do you've then got *two* problems. You still have the underlying tension — which will become only too apparent when you run out of sedatives. And you've become a drug addict as well.

To fully appreciate the efficacy of GSR machines in tension reduction it should be understood that there is an almost one-for-one relationship between mind and body. If you reduce muscular tension you will automatically reduce mental tension which in turn will reduce muscular tension yet further — and so on.



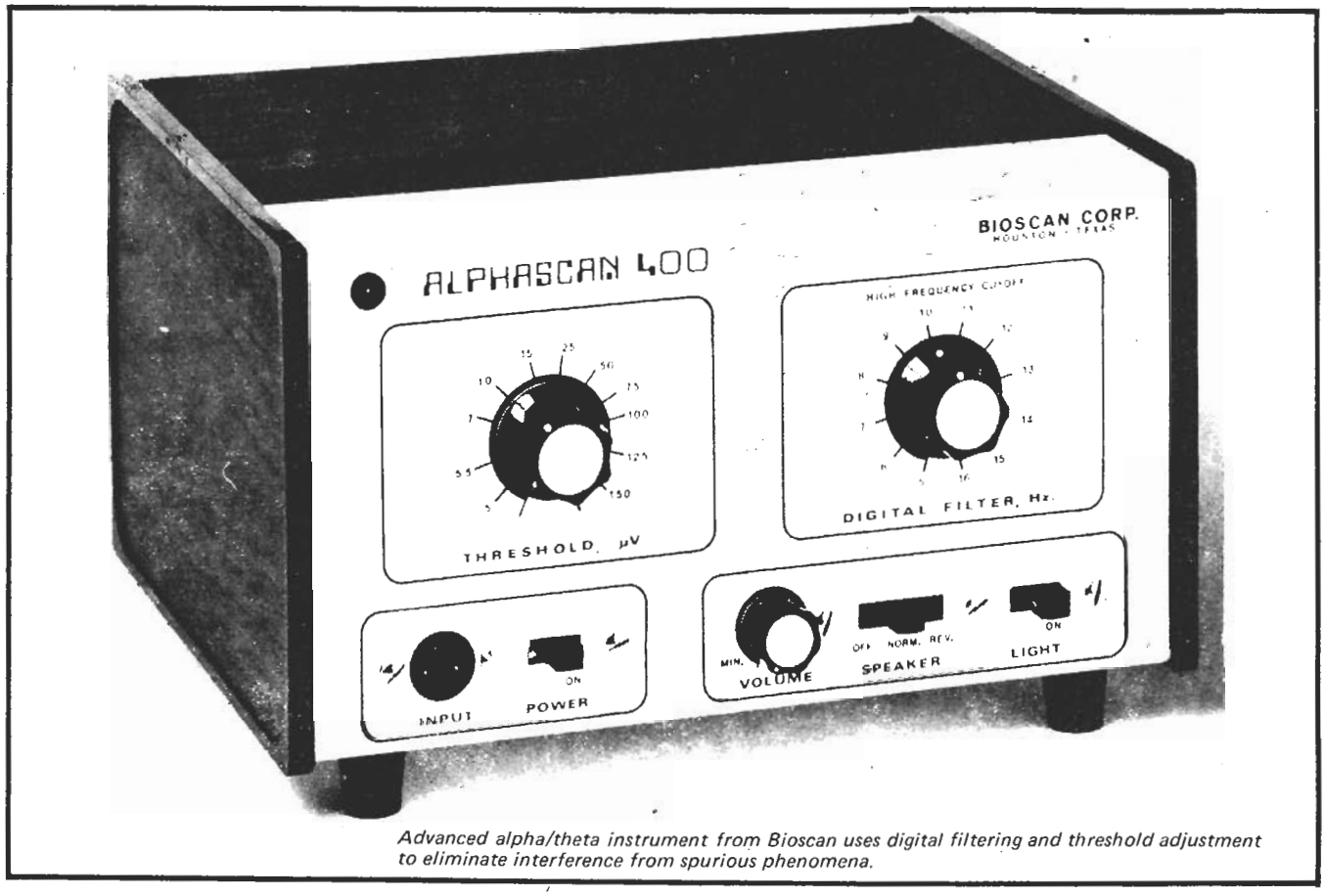
Temperature trainer from Huma-Tech Industries has three ranges each switchable to provide 0-10° or 0-1° fsd.

TEMPERATURE MONITORING

Tension is also reflected in skin temperature — particularly in the hands. A considerable amount of work in this field has been performed by Green and Green of the USA's Menninger Foundation research dept, who use this technique extensively in the control of migraine.

As with GSR, the technique and equipment is remarkably simple. Subjects are simply taught to raise their hand temperature — meanwhile monitoring the effect on an expanded-scale temperature meter. A small thermistor is taped to a finger tip to monitor changes and the output from this is backed off against a second thermistor within the instrument to compensate for ambient temperature changes.

instant yoga



Advanced alpha/theta instrument from Bioscan uses digital filtering and threshold adjustment to eliminate interference from spurious phenomena.

At a recent demonstration (attended by the writer) some fifty subjects with no previous experience of temperature training all succeeded in varying their hand temperature (in some cases by as much as 5°C within a single twenty minute session).

If you're contemplating building your own temperature monitor choose thermistors with a two to three second response time. Build the thermometer so that ambient temperature can be backed off, thus enabling the meter to give a centre zero indication at the beginning of the experiment. The instrument should have two switchable ranges — ±2.5°F and ±7.5°F.

As with GSR machines the readout may be either a tone of varying pitch and/or a meter reading.

People teach themselves to use these devices very quickly — usually within ten to fifteen minutes. However, whilst almost everyone can effect a change of temperature, about 50% will find the change to be in the opposite direction to that intended! Nevertheless the correct technique is quickly acquired after a few more minutes.

ELECTROMYOGRAPHS

Feedback electromyographs (EMGs) provide information about muscular tension by visually and aurally displaying neuron firings caused by muscular activity. They are commonly used in both clinical and research applications for the observation and reduction of stress and anxiety, tension and migraine headaches, tension backaches, muscle spasms and tics, essential hypertension etc.

Unlike the far simpler GSR and temperature indicators, myographs necessarily need sophisticated electronic circuitry in order to monitor the very low level activity of neuron firings.

The actual signals are picked off by silver, silver-chloride or gold electrodes placed on the surface of the skin directly across the muscle concerned. In some cases the signal may be obtained via implanted electrodes.

Signal level is very low — often as small as 0.1 microvolts, so noise rejection must be high. A typical unit will have common mode rejection of better than 100 dB. A bandpass filter is usually incorporated. This typically rolls off at 18 dB/octave beyond 100–500 Hz. The output signal is generally averaged over an adjustable 0.5 to 5 second period.

This type of instrument is not really suitable for home designing or building.

HEART RATE

The heart is simply a four-chambered pump. It receives circulating blood, causes the blood to be pushed into the lungs where it picks up oxygen, then causes this blood to be returned to the heart and finally and very powerfully this re-oxygenated blood is forced through the body.

The rate at which the heart beats appears to be directly related to the metabolic requirements of the body, but the way in which this is done is not currently understood. However virtually every part of the brain yet examined appears to play some part in the determining and controlling heart rate.

Short of simply feeling one's pulse and timing it with a stopwatch, the next simplest method is to monitor fluctuations in blood density as the pulse occurs. This may be done opto-electronically using a simple light source and photocell attached across an ear-lobe or finger tip.

There is growing evidence that the ability to control heart rate via a biofeedback process would be of value in protecting it from undue stress. As with most biofeedback activities it is very easy to do this given the correct apparatus. Yogis have, of course, gained such

biofeedback

control *without* apparatus. Nevertheless it should be emphasised that less appears to be known about heartrate control than galvanic skin response or myography.

BRAINWAVE MONITORS

The brain produces four major electrical rhythms, classified by frequency. These rhythms may be monitored by an electroencephalograph (EEG) which detects, amplifies and displays them electrically.

The major rhythms are –

Beta: 13-30 Hz – associated with attention, anxiety.

Alpha: 8-12 Hz – associated with relaxation, well being.

Theta: 4-8 Hz – associated with imagery, meditation.

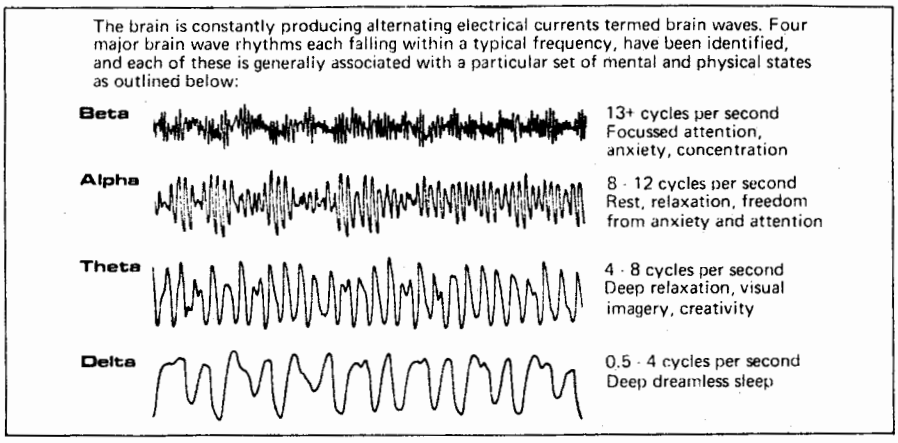
Delta: 0.5-4 Hz – associated with dreamless sleep.

Generally the rhythms are produced in short bursts – often of 10–25 cycles – and generally non-overlapping.

The signals may all be monitored via one set of electrodes placed at the front and rear of the skull – a third electrode is also used to provide a 'reference'.

All four rhythms have very low amplitude – about a microvolt or two – so that good noise performance is essential if the equipment is to function correctly.

Very good filtering is also required to eliminate interference from stray 50 Hz signals and also to prevent interference from artifacts (spuria generated by muscular activity). Analogue filters having the required characteristics can be produced but digital filters should preferably be used. If an analogue filter is used, a good one is a three-pole Butterworth with 18 dB/octave rolloff.



It is almost essential to use a differential input amplifier using low noise devices. Input cables must be shielded. Common mode rejection should be about 120 dB at 10 Hz and if possible at least 150 dB at 50 Hz. Input impedance should be no less than one megohm. The output indication should be aural. Most people prefer to have their eyes closed when trying to generate alpha rhythms.

Alpha training has become somewhat of a cult – particularly in the USA where a large industry exists simply to supply alpha monitors (of varying efficacy!)

Most people can learn to generate alpha rhythms at will and there is a great deal of evidence that a state of well-being and deep relaxation is associated with alpha production.

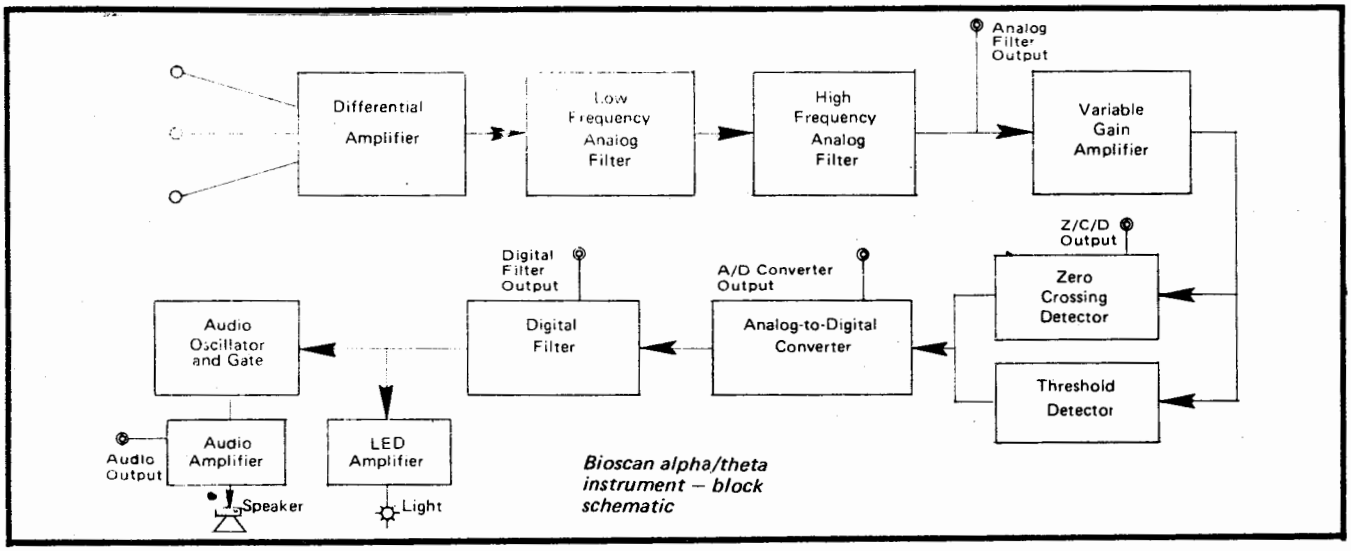
Alpha training is also used by clinical psychologists and psychiatrists particularly in attitude change and re-inforcement.

Theta waves are also controllable. This type of waveform appears to be in some way associated with creativity. It may well be that creativity can be enhanced by learning to control a theta state: we understand that some researchers are investigating this at present.

Biofeedback is still very much an infant and largely orphan science and at present it is difficult to forecast just what impact it will have on mankind.

There is ample evidence that by using biofeedback the average subject can in minutes learn to vary his state of tension, body temperature, heart rate, brainwave generation etc – techniques which have taken gurus a lifetime to master.

Many autonomic nervous functions clearly *can* be willfully controlled and there is growing evidence that many tension-related illnesses (and about 90% of illnesses are currently believed to be so related) can be alleviated or cured by biofeedback techniques. ●



Bioscan alpha/theta instrument – block schematic

BUILD A BIOFEEDBACK MONITOR

JIM BARBARELLO

Feeling tense? Then let your computer calm you down.

Although most persons think of the IBM PC primarily as a business computer that grinds its way from 9 to 5 through spreadsheets, databases, and documents, it can also be made to serve other, quite-different roles. One such application is as a computer-assisted biofeedback monitor.

Biofeedback is the process of monitoring a biological function that indicates your level of tenseness, and then feeding back that information to you in real time. By allowing you to see what happens when you try to relax, biofeedback lets you discover the techniques that work best for you. You can then practice those techniques to gain more control over daily tension and stress.

One biological function that indicates tenseness is your galvanic skin response, usually called simply GSR, which in non-medical terms simply means the resistance of your skin. As you become more tense, your rate of perspiration increases, thereby lowering the resistance of your skin. As you become less tense—as you "calm down"—the perspiration rate slows and your skin's resistance increases. A variation from your normal or average GSR is therefore an accurate biofeedback indicator of how tense or calm you are at a given instant in time. If you then use a computer to store a record of how tense or calm you were over a period of time, the same computer can provide you with a listing or a graphic display of the effectiveness of your efforts at reaching mental nirvana.

Measuring GSR

The easiest, and certainly the most simple way to measure GSR would be with an analog resistance-measuring device such as an ohmmeter. Unfortunately, analog measurements are not well-suited to digital computers. There is, however, a surprisingly simple alternative. By using a circuit that generates a digital pulse whose duration is proportional to a resistance, we can use a computer to measure the length of the pulse and then interpolate the pulse-length into a resistance value. That approach forms the basis for a biofeedback monitor for IBM PC-type computers. The monitor's schematic is shown in Fig. 1.

Integrated circuit IC1 is a 555 timer that is configured as a simple pulse generator. The width of its output pulse is the product of capacitance C1, resistance R1, and the skin resistance present between probes A and B. Since C1 and R1 are constant, any change in the pulse width is the direct result of a change in the resistance between probes A and B. Now all we need to do is to trigger IC1 to force its ouput, output pin 3, high, and measure the period of time until the output on pin 3 goes low (returns to ground—the end of the pulse).

The printer port

It may seem strange, but the computer's LPT1 parallel-printer port is the ideal way of interconnecting the biofeedback monitor to the computer. The PC's printer port has a number of input and output lines that are normally used to do things like initialize the printer and check for a busy status. Connector PL1 attaches to the PC's printer port. Pin 16 of the connector, the INIT line, connects to IC1's trigger input, pin 2. Sending out a short INIT pulse from the computer triggers IC1 and causes IC1's output, pin 3, to go high. Pin 3 goes low at the end of the pulse.

Pin 11 of PL1 is the computer's BUSY line. If we have the computer check for a low on pin 11, it will know when IC1's pulse has ended.

The common ground between the computer and the biofeedback monitor is through PL1 pin 20. Switch S1 applies power to the circuit through series-connected

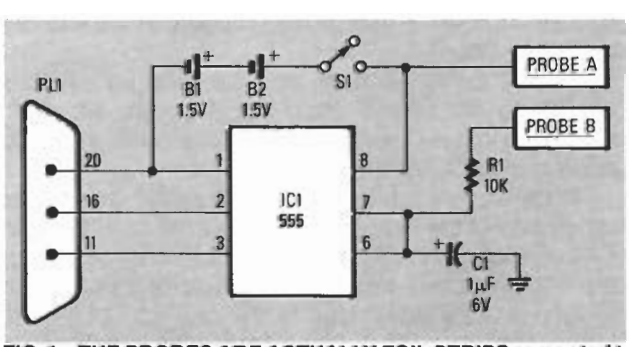


FIG. 1—THE PROBES ARE ACTUALLY FOIL STRIPS cemented to the top of the plastic case that houses the circuit. Because absolute stability is needed, batteries B1 and B2 should be secured by a holder, rather than be simply soldered into the circuit.

batteries B1 and B2. The batteries provide only 3 volts, so the output of IC1 will also be about 3 volts instead of the more usual 5 volts. Although 3 volts is much less than 5 volts, it is high enough to be sensed by the computer's printer port.

The software

The simplicity of the hardware is made possible by the fact that the software does most of the work in creating a screen display of your GSR. Let's look at some of the more important aspects of the program, called *PCBIO*, that is shown in Listing 1 and available on the REBBS (516-293-2283).

Line 30 looks to see if a printer port is installed and determines its address. Line 50 uses that information to set the addresses for the trigger input (T) and output (G) to the circuit. Line 190 begins the process of initialization. Since each person's GSR is different, the program takes five initial samples and averages them to determine a mid-range value (Y in line 220). Line 220 also calculates an increment value (INC) used to determine the range from full calm to full tense. Those range values are stored in array L in line 230.

The actual monitoring process begins in line 250. A call to the subroutine at line 320 gets a sample from the hardware as a count stored in variable X. Lines 280 and 290 determine where the tenseness indicator should be and places it there. The monitoring session ends when either full calm is reached (L>22 in line 280) or when you press the ESC key during monitoring (C = 27 in line 260).

The subroutine at line 320 interfaces with the hardware. Line 330 generates a short negative-going pulse to trigger IC1. Line 340 begins counting the time by incrementing variable X and checks to see if IC1's output has returned to zero (INP(G) = 127). When it does, line 350 checks to see if another sample should be taken (Z<XF). Variable XF is a scaling factor used to ensure that the count returned in variable X will always be above 100 (lower counts make the gauge displayed on the screen respond too quickly, and are distracting during the monitoring session). The commands LOCATE 1,60:PRINT X;: in line 350 display the actual count number just past the title on the screen display. The number may be removed.

Construction

The circuit can be assembled on a small scrap of perforated wiring board, which is installed along with a battery holder in a Radio Shack *270-220*, or similar, plastic case. Simply pass the components' leads through the appropriate holes and solder them together on the underside of the board.

Glue the battery holder into the case, as close as possible to one end. If you'd like to secure the circuit board, it, too, can be glued to the case with a drop of silicon rubber (RTV) adhesive or caulk.

The probes are simply two aluminum foil strips glued to the cover of the case; they are connected to the circuit by wires that run inside the case. Cut two strips of ordinary household aluminum foil to a size of 2 × ¾-inch. Apply a drop of white glue to the dull side of the foil. Then, as shown in Fig. 2, place the foil (glue side down) on the cover of the case, smoothing out the foil and removing any excess glue that squeezes out with a damp cloth. Let the glue dry for at least one hour and then drill

LISTING 1

```
1 REM$$         PC Biofeedback Monitor Program
2 REM$$         NAME: PCBIO
3 REM$$         c 1987, JJ Barbarello, Manalapan, NJ 07726
4 REM$$         V870911
10 CLEAR:DEFINT G,X:G=0:X=0:DEFSTR A,B:A=CHR$(232):B=SPACE$(2)
20 COLOR 0,6,6:CLS:KEY OFF:WIDTH 80:DIM L(22)
30 DEF SEG=64:PA=PEEK(8)+256*(PEEK(9))
40 IF PA=0 THEN COLOR 7,0,0:CLS:GOTO 430
50 A=CHR$(232):B=SPACE$(2):G=PA+1:L=13:T=PA+2:LOCATE 1,23,0
60 PRINT STRING$(5,16);" P.C. BIOFEEDBACK MONITOR ";STRING$(5,17)
70 LOCATE 2,37:PRINT CHR$(201);STRING$(5,205);CHR$(187)
80 FOR I=3 TO 22:LOCATE I,37:PRINT CHR$(204);B;A;B;CHR$(185):NEXT
90 LOCATE 23,37:PRINT CHR$(200);STRING$(5,205);CHR$(188)
100 LOCATE 3,31:PRINT"TENSE ";CHR$(206)
110 LOCATE 13,29:PRINT"AVERAGE ";CHR$(206)
120 LOCATE 22,32:PRINT"CALM ";CHR$(206):PLAY "L64"
130 FOR I=3 TO 22:LOCATE I,40:PRINT" ":P$="N"+STR$(60-I$2):PLAY P$:NEXT I
140 FOR I=22 TO 13 STEP -1:LOCATE I,40:PRINT A:P$="N"+STR$(60-I$2)
150 PLAY P$:LOCATE I,40:PRINT" ":NEXT I:LOCATE 13,40:PRINT A
160 LOCATE 24,22,1:PRINT"Press <ENTER> to begin, or <ESC> to end...";
170 AA=INPUT$(1):C=ASC(AA):IF C=27 THEN 400 ELSE IF C<>13 THEN 170
180 LOCATE 24,22,0:PRINT SPACE$(42);
190 LOCATE 24,34:PRINT"INITIALIZING...";:Y=0:PLAY"L64":XF=1
200 GOSUB 320:IF X<100 THEN XF=XF+1:PLAY "164;N32":GOTO 200
210 FOR I=1 TO 5:GOSUB 320:PLAY "L64;N34":Y=Y+X:NEXT I
220 Y=Y/5:INC=Y/100:LOCATE 24,28:PRINT"Press <ESC> to End Trial.";
230 PLAY"L32":LOW=Y-10$INC:FOR I=3 TO 22:L(I)=LOW+(I-2)$INC:NEXT
240 REM$$ MONITORING
250 P$="N"+STR$(60-(L$2)):PLAY P$:IF X=0 THEN 360
260 AA=INKEY$:IF AA<>"" THEN C=ASC(AA):IF C=27 THEN 370
270 GOSUB 320
280 IF X>L(L) THEN LOCATE L,40:PRINT" ":L=L+1:IF L>22 THEN 370 ELSE LOCATE
    L,40:PRINT A
290 IF X<L(L) THEN L=L-1:IF L<3 THEN L=3 ELSE LOCATE L+1,40:PRINT " ":LOCATE
    L,40:PRINT A
300 GOTO 250
310 REM$$  SAMPLING SUBROUTINE
320 X=0:Z=0
330 OUT T,0:OUT T,4
340 X=X+1:IF (INP(G) AND 128)=0 THEN 340
350 Z=Z+1:IF Z<XF THEN 330 ELSE LOCATE 1,60:PRINT X;:RETURN
360 REM$$ TRIAL END
370 LOCATE 13,8,1
380 PRINT"TRIAL COMPLETED.  Press <ENTER> to try again, or <ESC> to end...";
390 AA=INPUT$(1):C=ASC(AA):IF C=13 THEN CLS:GOTO 50 ELSE IF C<>27 THEN 390
400 COLOR 7,0,0:CLS:LOCATE 10,28,1:PRINT"MONITORING SESSION OVER"
410 LOCATE 13,1:END
420 REM$$ CAN'T FIND STANDARD PRINTER PORT
430 LOCATE 10,27,1 PRINT"PRINTER PORT 1 NOT AVAILABLE":PRINT:PRINT:END
```

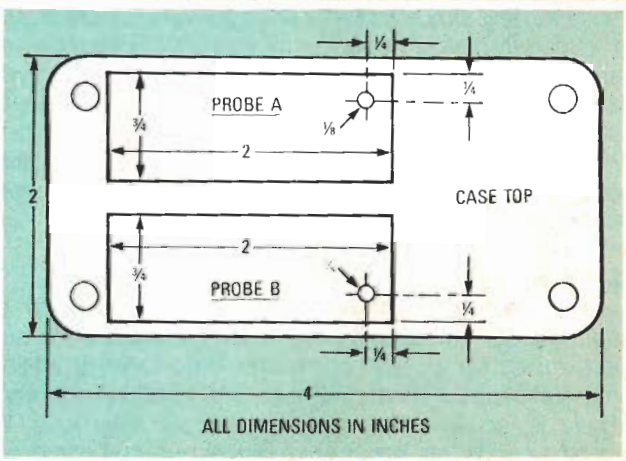


FIG. 2—IT'S NOT ALL THAT CRITICAL, but this kind of installation for the foil strips on the cover of the specified case will prove the most convenient for all sizes of hands and fingers.

two ⅛-inch diameter holes at the locations shown in Fig. 2. Place two 4-40 × ¼-inch machine screws through the holes and loosely screw a 4-40 nut onto each screw. Wrap the bare end of either of the wires from the circuit board

around either of the screws and tighten the nut. Repeat the procedure for the remaining wire and screw. Figure 3 shows how the prototype was assembled.

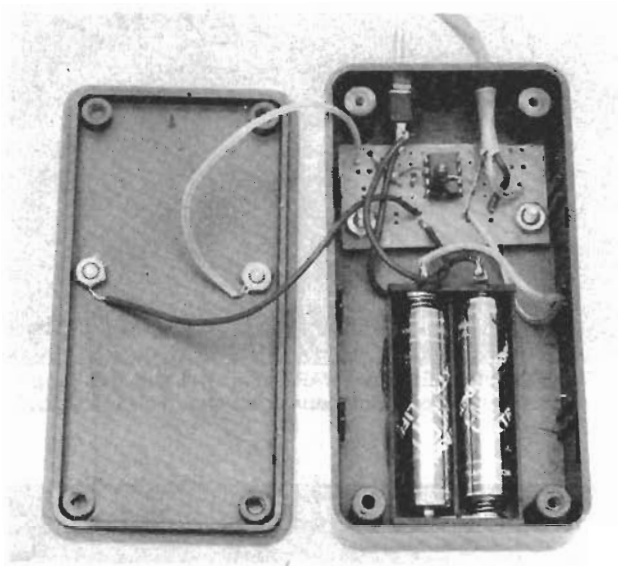


FIG. 3—THE COMPLETED PROTOTYPE. Notice how the wires to the foil strips simply connect to the screws that pass through the cover.

PARTS LIST

IC1—555 timer
R1—10,000 ohms, ¼-watt, 10% resistor
C1—1 µF, 6-volt, Tantalum capacitor
B1, B2—1.5 volt, AAA battery
PL1—25 pin D-connector
S1—SPST switch
Miscellaneous—Plastic case, battery holder, perforated wiring board, wire, solder, machine screws, etc.
Note: A compiled, enhanced version of the *PCBIO* program is available on 5¼-inch diskette from JJ Barbarello, RD #3, Box 241 H, Tennent Road, Manalapan, NJ 07726. Price of $7 includes postage and handling. NJ residents must add appropriate sales tax. If known, indicate the type of computer and its clock speed.

Using the monitor

Connect PL1 to your computer's parallel printer port, apply power to the monitor by closing S1, then load BASIC and the PCBIO program in your computer. When you run the program, the computer will create the screen shown in Fig. 4. In the center is a tenseness gauge resembling a thermometer. The top of the gauge is maximum tenseness, the bottom of the gauge is maximum calm, and the center of the gauge (where you begin) is average. The message on the bottom of the screen asks you to press ENTER to begin monitoring, or ESC to end the session.

The room you're in should be comfortable (about 70°F). Sit in a chair that provides good support and loosen any tight clothing. Place the biofeedback monitor unit next to you on a table or stand that can support the unit and your forearm. Make sure your fingers are free of oil or excess perspiration. Rest your forearm on the stand in front of the unit, place your first (index) finger on one probe and your second finger on the other probe. It is

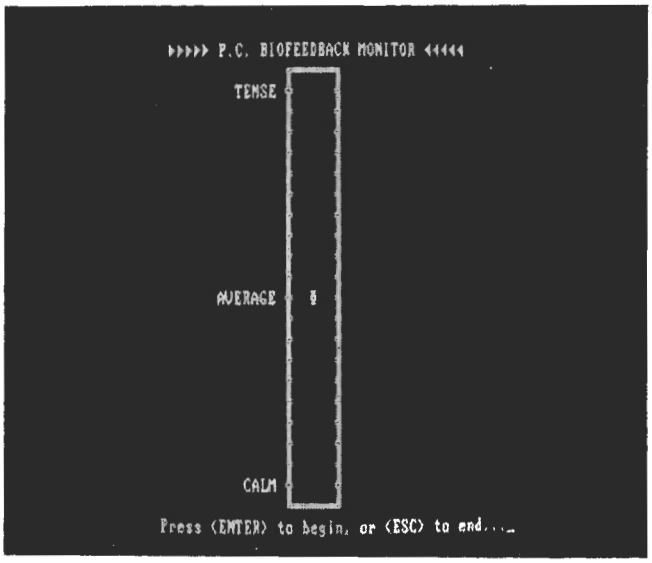


FIG. 4—THE OPENING SCREEN shows a thermometer-type device that ranges from calm to tense.

very important that you do not move your fingers or change the pressure on the probes during the monitoring session, as that will change the resistance between the probes and give a false reading.

Press the ENTER key with your free hand. The message on the bottom of the screen will change to "INITIALIZING" and you will hear a series of beeps as the system measures your initial level of tenseness. After a short time, the message on the bottom of the screen will change to "Press C to End Trial"; you are now monitoring your changing level of tenseness. That's indicated by the moving cursor in the middle of the gauge, and a beep with a changing tone. As you become more tense, the beep's frequency and the indicator ascend, as shown in Fig. 5. When you calm down, the beep's frequency and the indicator descend, as shown in Fig. 6. The session will end when you either press the ESC key or reach maximum calm (nirvana?). The message "TRIAL COMPLETED. Press Enter to try again, or Escape to end" will appear in the middle of the screen. When you end the session, the

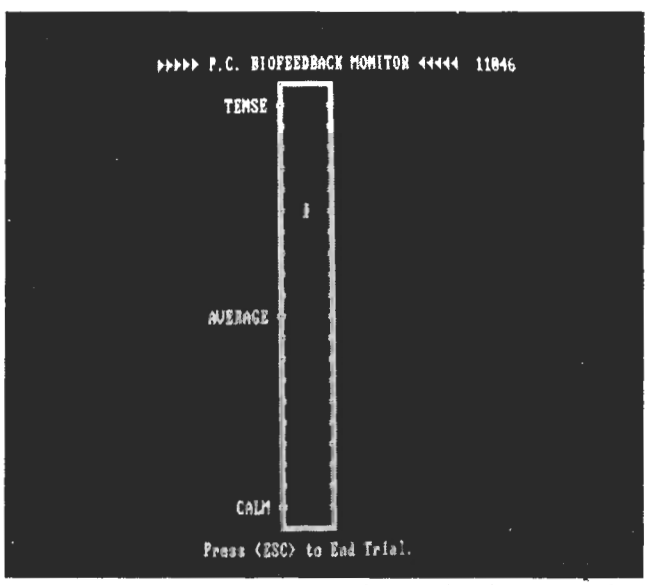


FIG. 5—IF YOU'RE TENSE, the indicator will slide up the thermometer and tone from the computer's speaker will rise in pitch.

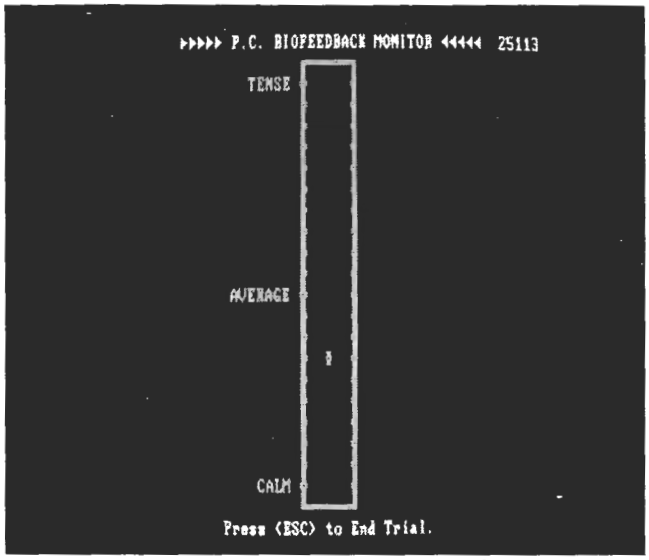


FIG. 6—THE CALMER YOU GET the lower the indicator's position, and the lower the tone heard from the speaker.

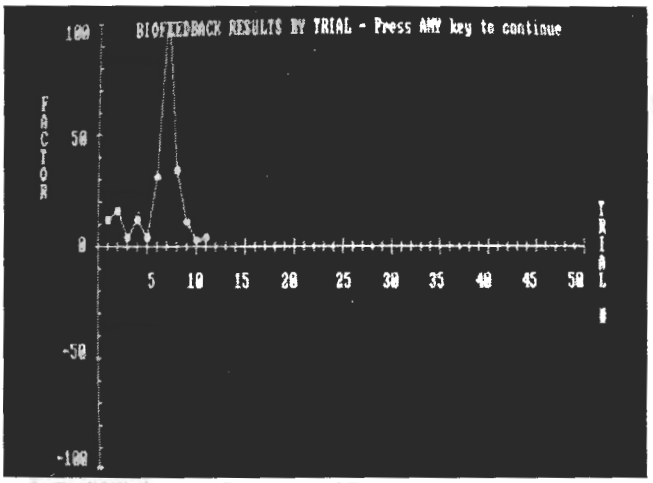


FIG. 7—THE COMPILED SOFTWARE will store and then graphically plot the results of a biofeedback session. This is the standard display.

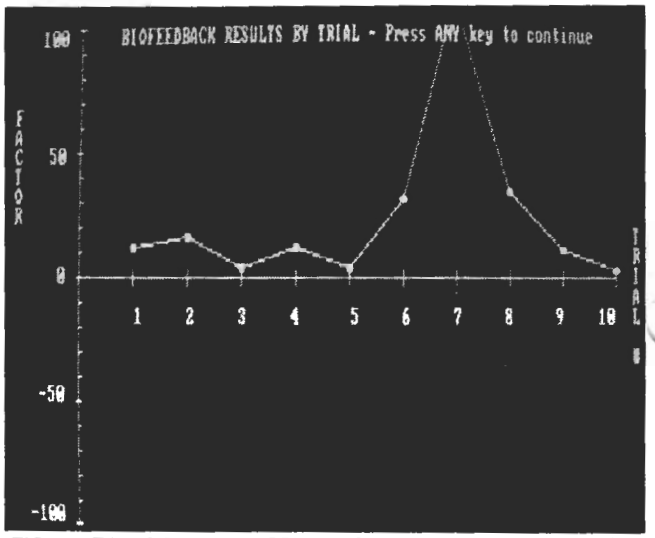


FIG. 8—FOR A MORE PRECISE EXAMINATION of your session, the plot can be expanded.

screen will clear except for the message "MONITORING SESSION OVER."

To test the unit, begin monitoring. Press down hard with your two fingers to simulate increased perspiration (tenseness). The indicator should begin to rise. Release the pressure and note that the indicator begins to fall. Press ESC to end the trial. When you are sure that the unit is working properly, you can begin actual monitoring.

You should now try to concentrate on different images or thoughts and note the results on the gauge. At first it may seem that trying to calm down actually increases tension. That is normal because the untrained mind tends to race through both conscious and unconscious thoughts. Through practice you will learn how to focus on the images and thoughts that actually decrease tension—disregarding everything else, and use them to assist you in your calming process.

Tweaking

The software monitoring subroutine is sensitive to the speed of your computer. The program listing contains the factor "IF X <100" in line 200 to adjust it for use on a standard 4.77-MHz computer. Computers operating at 8 MHz, or AT systems, will respond more quickly and produce a higher count for the same amount of time and seem to be racing along. To compensate for racing, simply change the "100" in line 200 to a higher number (try 300 as a starting value, and adjust it until you are comfortable with the speed).

Enhanced software

The program may have some difficulty with some versions of BASIC on floppy-disk-only systems. If that is the case, you will notice the indicator move very slowly when you initially run the program (normally the indicator zips down the gauge and then back up to "AVERAGE"). If you experience the problem, a compiled version of the program is available from the source given in the parts list. It is an executable program that runs in DOS and, thus, does not require the use of BASIC. The compiled program has also been enhanced to include storage and analysis of results: both lists and graphic plots. Figure 7 shows a standard plot display of a monitoring session. Figure 8 shows the same session using the program's expanded plot feature.

Closing thoughts

The biofeedback monitor is basically just a self-learning type of device, that also happens to be a lot of fun. It is not meant to take the place of any necessary medical treatment or equipment. However, with practice, the device can help you learn how to reduce everyday stress and tension. Sooner or later you'll find that you do have the ability to mentally calm and relax yourself. It's just a matter of finding the technique that's right for you.

Another interesting point is that GSR is one measure that is used by polygraphs (lie-detector) to determine whether or not someone is lying. For that reason, the device can be used as a rudimentary "lie detector" for general entertainment at parties and gatherings. We're sure that you'll find many other interesting uses for the biofeedback monitor—perhaps you can even modify it so that you can monitor other bodily functions. If you do, why don't you drop us a note and let us know about."