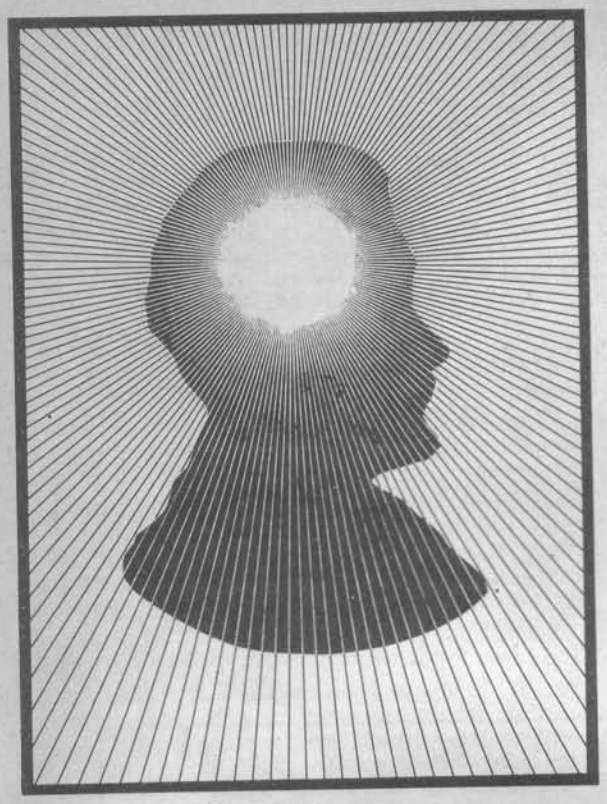


Biological Amplifier

By D. BOLLEN

THIS month we describe the construction of a brain rhythm frequency meter and cardiophone.

BRAIN RHYTHM FREQUENCY METER

The circuit in Fig. 8 can be employed to identify different brain rhythms, and will demonstrate, for example, how alcohol intake affects alpha frequency.

A signal taken from output 1 of the pre-amplifier is amplified by TR3 and squared by the Schmitt trigger TR4 and TR5. Differentiator C15 and VR4 converts the square wave into an a.c. signal of amplitude proportional to frequency. This is rectified and smoothed by D3, D4, and C16, with the resulting d.c. current being measured by ME2. VR4 calibrates the instrument, and VR3 adjusts sensitivity.

The frequency range covered by ME2 is 0-20Hz, and capacitor C8 in the pre-amplifier can be switched into circuit by S3 to give additional top-cut for noise and interference rejection, see Fig. 2.

In addition to the frequency meter, a voltage controlled unijunction oscillator TR7, gives an audio output into 8 ohm headphones of frequency proportional to the subsonic brain rhythm frequency, so that the user can sense changes of rhythm with his eyes closed. TR6 controls the charge rate of the unijunction emitter capacitor C17.

If interest is centred on either beta, theta, delta, or slow alpha rhythms, the centre frequency of the pre-amplifier can be modified according to the capacitor value listed in Fig. 3. Alternatively, a three-pole four-way wafer switch can be used to select twin-T filter capacitance values.

CONSTRUCTING AND USING THE FREQUENCY METER

Constructional details of the frequency meter output module are shown in Fig. 9. A suggested layout in a metal box, similar to that used for the alphaphone, will be found in Fig. 10. C16 is mounted on the meter terminals.

Plug headphones into SK4, leave the head electrodes disconnected from SK1 and SK2, and set VR1 and VR2 to minimum resistance, and VR3 and VR4 to maximum resistance. Switch on the

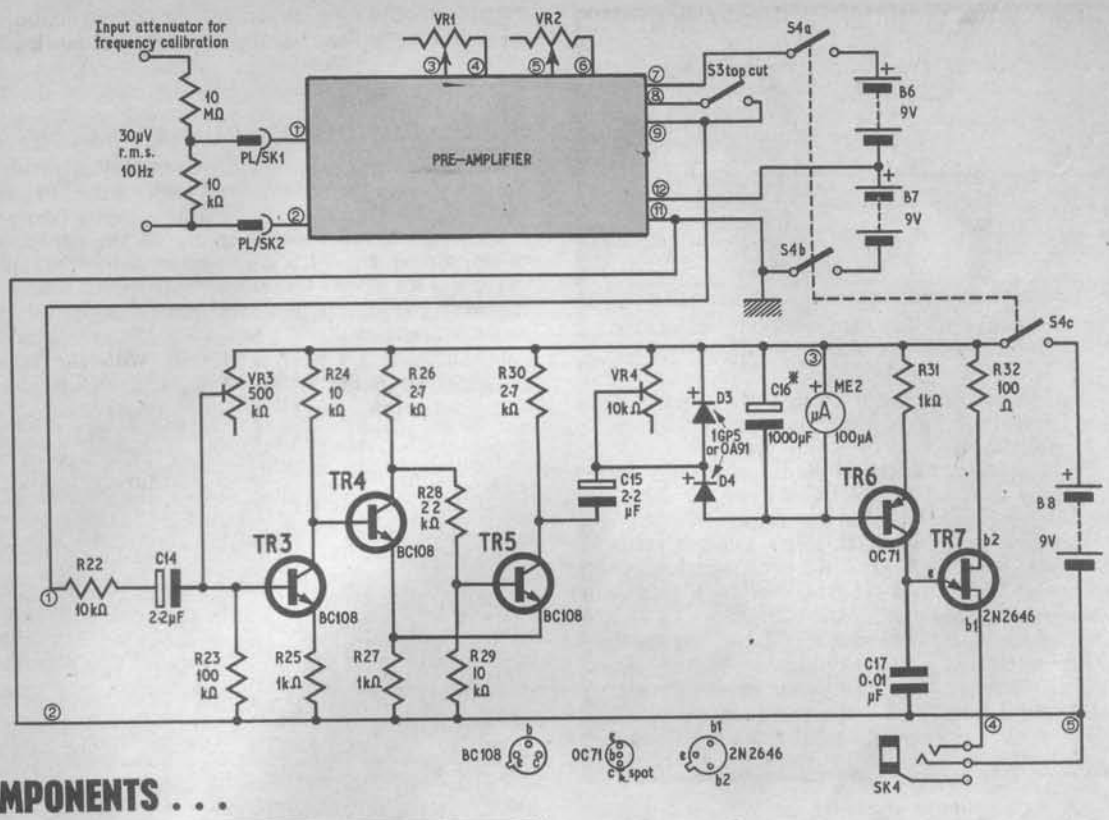


Fig. 8. Wiring of the pre-amplifier to the frequency meter circuit to measure brain rhythm rates

COMPONENTS . . .

ADDITIONAL COMPONENTS FOR FREQUENCY METER

Resistors

R22	10kΩ	R26	2·7kΩ	R30	2·7kΩ
R23	100kΩ	R27	1kΩ	R31	1kΩ
R24	10kΩ	R28	22kΩ	R32	100Ω
R25	1kΩ	R29	10kΩ		

All ±10% ½ watt carbon

Potentiometers

VR3 500kΩ sub-min horizontal pre-set
VR4 10kΩ sub-min horizontal pre-set

Semiconductors

TR3	BC108	TR6	OC71
TR4	BC108	TR7	2N2646
TR5	BC108	D3, D4	IGP5 or OA91

Capacitors

C14 2·2μF tantalum 35V
C15 2·2μF tantalum 35V
C16 1,000μF elect. 3V
C17 0·01μF polyester

Meter

M2 100μA edgewise type level indicator

Switches

S3 single-pole, on-off sub-miniature
S4 3-pole, 2-way wafer

Socket

SK4 3-pole jack

Batteries

B6, B7, B8 9 volt style PP3 (3 off)

Miscellaneous

8 ohm mono or stereo headphones, electrodes, battery connectors, metal box.

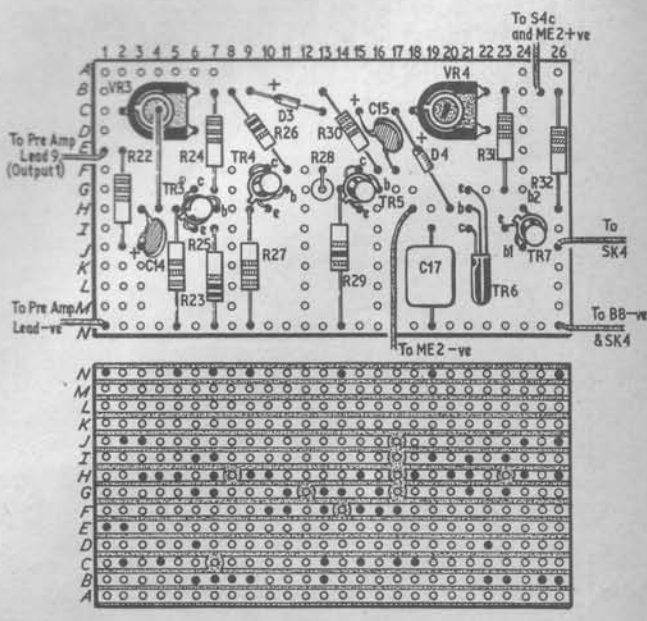


Fig. 9. Layout and wiring of the frequency meter board

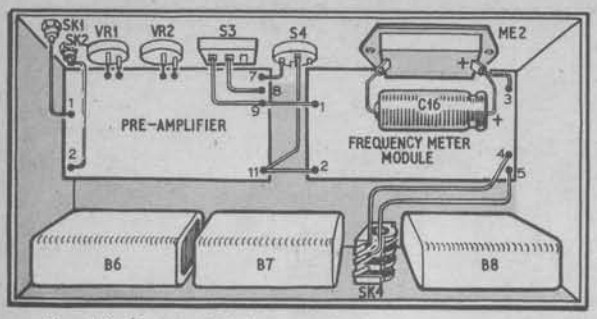


Fig. 10. Suggested layout of components for the brain rhythm frequency meter circuit shown in Fig. 8

instrument and listen for a steady low note in the phones. Advance VR3 until the audio note just starts to rise slightly.

If an accurately calibrated audio oscillator with an output of around 30 millivolts r.m.s. at 10Hz is available, connect this to the pre-amplifier input via a 10 megohm resistor, with a 10 kilohm resistor shunting SK1 and SK2. Set VR1 for a steady deflection of meter ME2, and adjust VR4 for a half full scale reading, corresponding to 10Hz.

In the absence of an audio oscillator, set up the frequency meter for alpha rhythms (with head electrodes on a subject who can generate steady alpha rhythms) and adjust VR4 for a mean meter reading of 10Hz. With the eyes open, ME2 should fluctuate between 2-7Hz, indicating the presence of random brain noise and low level theta.

As an experiment, measure a subject's alpha frequency and then ask them to have a drink (alcoholic). After 15-30 minutes the alpha frequency should fall by several hertz. A whole range of experiments can be conducted with the frequency meter, such as mental reactions to various stimuli, or the effect of dreams on sleep rhythms.

ELECTRODE SITING

With previous projects the earthed electrode (SK2) was sited on the forehead so that eyeblink signals could be used to test equipment in the absence of alpha rhythms, but in some investigations eyeblink pulses can be a nuisance. Alpha, theta, and delta signals are best obtained from the back of the head, with the earthed electrode positioned an inch or two from the live electrode. For beta signals the electrodes can be placed on the forehead or near the cheeks, but watch for noise generated by facial muscles and eyes.

If the earthed electrode is placed on the neck, or other parts of the body, while observing brain rhythms, a strong heartbeat pulse will be superimposed, tending to block the brain signals.

CARDIOPHONE

Stress situations, like running for a bus, attending an interview, sitting an exam, or appearing before an audience, are usually attended by an obvious increase in heartrate, but during the course of an uneventful day the heart also responds to numerous minor stress situations which normally pass unnoticed.

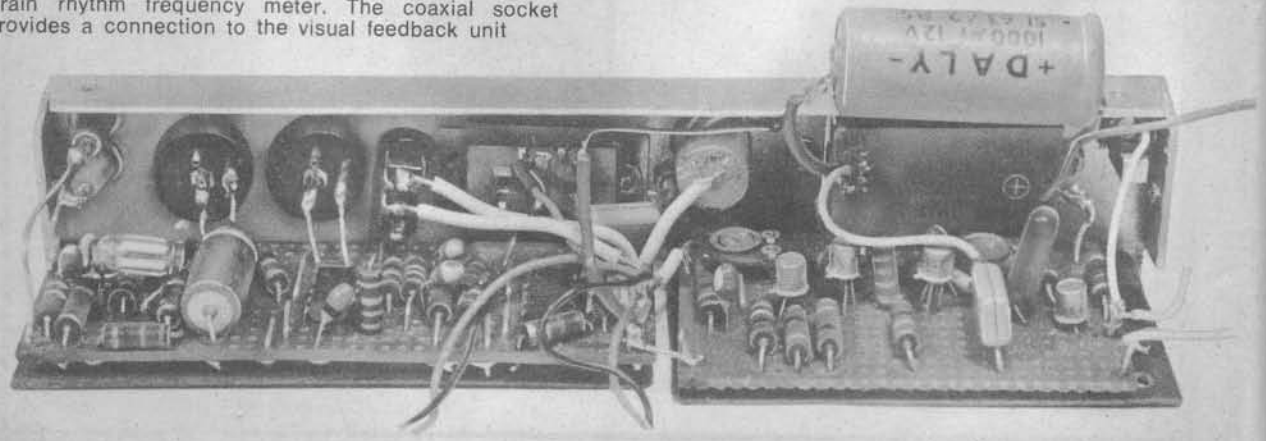
By making the heartbeat clearly audible, it is possible to detect these subtle changes, and perhaps learn to control them. This is really an example of bio-feedback. If the heart speeds up slightly in response to some unconscious stimulus, you become aware of it and seek to reduce it.

Conversely, it may also be possible to induce an artificial state of excitement by consciously trying to increase heartrate, and thereby cause more adrenalin to be released into the system.

In the cardiophone circuit (Fig. 11) transistor TR8 is in series with the emitter supply to astable multivibrator TR9 and TR10. In the absence of a heartbeat signal, TR8 base is grounded (by R16, Fig. 3) and the multivibrator is therefore switched off. Diode D1 in the pre-amplifier, rectifies a heartbeat signal and applies a positive going pulse to TR8 base, thus switching on TR8 and the multivibrator, and causing a 300Hz audio "bleep" tone to be heard in the earpiece X1.

Switch S5 in Fig. 11 gives additional top cut to suppress mains borne interference.

Brain rhythm frequency meter. The coaxial socket provides a connection to the visual feedback unit



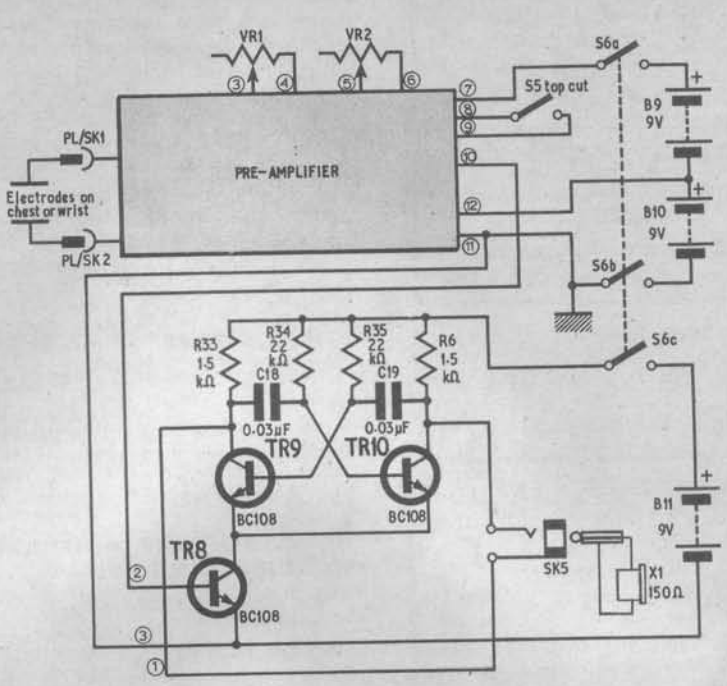


Fig. 11. The pre-amplifier used with a cardio-phone circuit

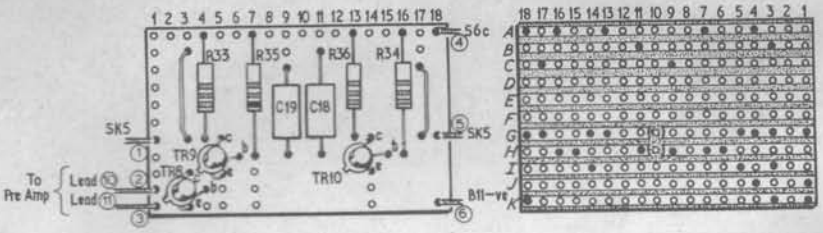


Fig: 12. Layout and wiring of the cardiophone output module

COMPONENTS . . .

ADDITIONAL COMPONENTS FOR CARDIOPHONE

Resistors
R33 1·5kΩ
R34 22kΩ
R35 22kΩ
R36 1·5kΩ
All ±10% ½ watt carbon

Capacitors
C18 0·03μF polyester
C19 0·03μF polyester

Transistors
TR8 BC108
TR9 BC108
TR10 BC108

Earpiece
X1 150 ohm magnetic

Switches
S5 Single-pole, on-off sub-miniature toggle
S6 3-pole, 2-way wafer

Batteries
B9, B10, B11 9 volt style PP3 (3 off)

Socket
SK5 3·5mm 2 pole jack

Miscellaneous
Electrodes
Battery connectors
Metal box (see text)

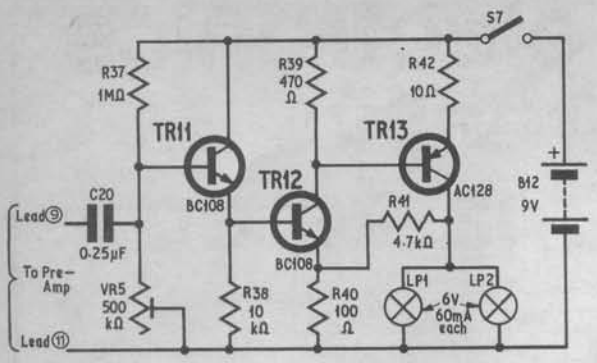


Fig. 13. Circuit of the visual feedback lamp driver

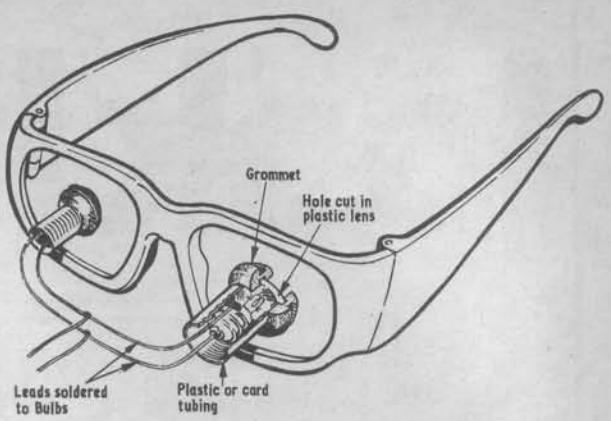


Fig. 14. The method of mounting the lamps in plastics lens sunglasses

COMPONENTS . . .

ADDITIONAL COMPONENTS FOR VISUAL FEEDBACK LAMP DRIVER

Resistors
R37 1MΩ
R38 10kΩ
R39 470Ω
R40 100Ω
R41 4·7kΩ
R42 10Ω
All ±10% ½watt carbon

Potentiometer
VR5 500kΩ sub-miniature horizontal mounting preset

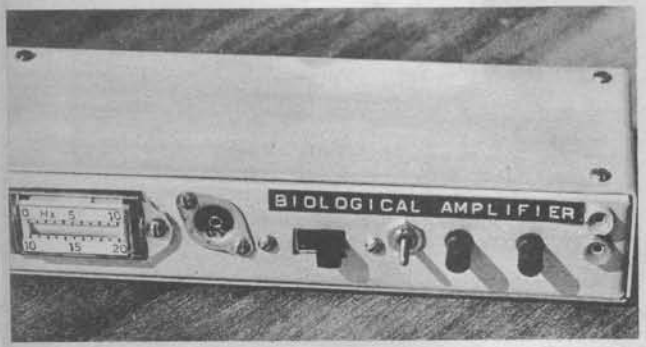
Capacitor
C20 0·25μF miniature polyester

Transistors
TR11 BC108
TR12 BC108
TR13 AC128

Switch
S7 Single-pole, on-off toggle or slide

Lamps
LP1, LP2 6V 60mA m.e.s.

Battery
B12 9 volt style PP9



Brain rhythm frequency meter. The coaxial socket provides a connection to the visual feedback unit

CONSTRUCTING AND USING THE CARDIOPHONE

The cardiophone output module circuit board (Fig. 12) may be housed, along with the pre-amplifier module, in a metal box similar to that used for previous projects. Socket SK5 must be insulated from the box.

Electrodes for use with the cardiophone can either be positioned a few inches apart on the left side of the chest, or one on each wrist, and held in place with elastic straps.

Set VR1 to minimum gain, and VR2 to wideband, with S5 open circuit. Plug earpiece X1 into SK5, the electrode leads into SK1 and SK2, and switch on. If no heartbeat "bleep" is heard, advance VR1. When the heartbeat is masked by interference, close S5, and adjust VR1 and VR2 for a clear signal.

Try using the cardiophone with a friend who is driving a car. The "bleep" rate will increase when negotiating roundabouts, traffic lights, and congested streets, and will rise sharply when overtaking.

VISUAL FEEDBACK

The lamp driver circuit in Fig. 13 can be employed as an external unit to extend the scope of previous projects. An output taken from the pre-amplifier (output 1) is amplified to a level sufficient to flash two low consumption filament lamps (LP1 and LP2) which are mounted close to the eyes in a pair of cheap plastics lens sunglasses; see Fig. 14.

When driven by brain rhythms, visual feedback will produce an interesting variety of "strobe" effects while leaving the ears free to, say, listen to music or other sound sources.

If the lamp driver circuit is housed in a small plastics box, it can be coupled to the alphaphone, alphameter, frequency meter, or cardiophone, via screened cable to a coaxial socket which connects with pre-amp output 1. VR5 is adjusted so that both lamps just glow when there is no signal. Setting up instructions are otherwise the same as for previous projects. ★

Note: pin 12 in the case interwiring diagram in Fig. 5 (last month) should be designated pin 11 to agree with the practical circuit.