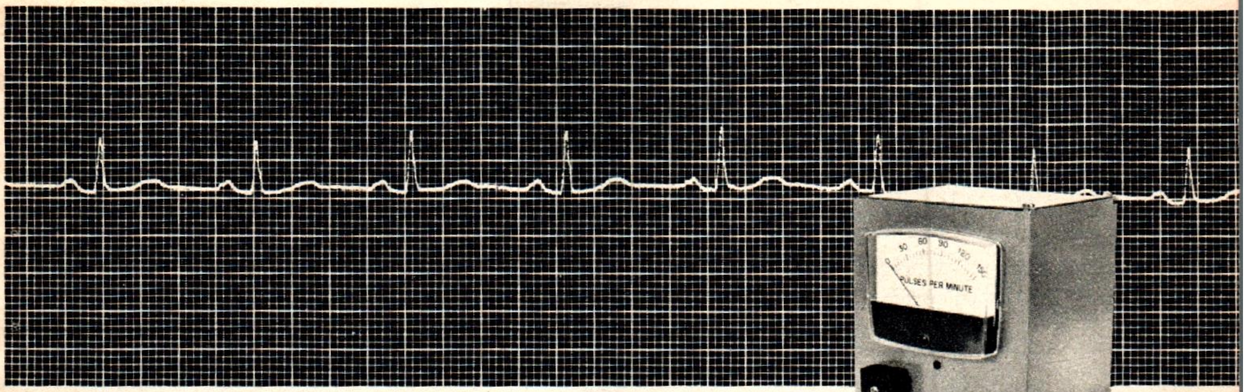

Build a Cardio-Tach

Don't feel your wrist. Lay a finger on the block and our cardio-tachometer instantly reads your pulse.

By HERB COHEN

EVERYONE has taken his own pulse at one time or another. Gently grasping the wrist until the throb of an artery is caught is one of the most basic of all medical tests. That strong, steady pulse can be an indication of a healthy heart, lungs and circulatory system.

Most non-medical people, however, have trouble locating a pulse point. But now it's no longer necessary to fumble with your wrist while you count the seconds with a watch. Place a finger over the pickup block on our Cardio-Tach. You'll be able to read your pulse directly—and in a few seconds.

A light-emitting diode shows you the duration of each pulse. Besides, it gives you a visual indication that your finger is correctly seated on the pickup block.

A lamp and photo transistor built into the pickup are the key to our Cardio-Tach. When your finger is placed on the block, some of the light is conducted through the fingertip flesh. As blood is pumped through the capillaries, light conductivity of the flesh changes. The photo transistor sees these changes as variations of light level and produces a small voltage pulse.

The lamp in the block is a miniature six-V bulb. It's powered by a regulated current source which insures constant light output as the bulb ages. The regulated source also reduces the chance of AC hum voltages leaking into the phototransistor from the lamp filament.

How It Works. Photo transistor Q1 picks up variations in light level caused by the blood pulsations. This signal is fed into transistor Q2, connected as an emitter follower. Some of the high-frequency components are removed by capacitor C2. The signal is further amplified by transistors Q3 and Q4.

Note that transistor Q4 has no external bias and conducts only when Q3 passes a pulse. Capacitor C5 also bypasses high frequencies to ground, making the Cardio-Tach fairly immune to AC-induced hum.

The amplifier voltage pulse is coupled to transistor Q5 via resistor R6. Both transistors Q5 and Q6 are coupled together as a bistable multivibrator. This circuit changes the shape of the pulse by converting it to one having a constant amplitude and sharp rise time.

Whenever transistor Q6 changes its conduction state, it drives transistor Q7 on. The LED, labelled D9 in the schematic, glows red for the brief time that Q6 conducts.

As soon as Q6 switches into its on state, capacitor C6 starts to charge through resistor R12. When the voltage across C6 rises above the gate voltage necessary to fire transistor Q12, it conducts. Transistor Q8 is driven on at the same time. Once it has fired, transistor Q12 will conduct as long as Q6 is also being driven.

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Transistor Q8 responds to two different voltage sources. If Q5 is conducting, transistor Q8 is turned on via current passing through diode D3.

The second voltage source presented to Q8 is transistor Q12. When it has fired, Q12's cathode current latches transistor Q8 into its *on* state. The only time Q8 is in its *off* state is the 50 milliseconds it takes capacitor C6 to charge.

The function of transistor Q8 is to short the output of Q10, a 10 ma. constant-current generator. Every time a pulse appears at the base of Q8, it turns off for 50 milliseconds. This gives Q10 time to charge up capacitor C7.

Since C7 is charged from a constant-current source for 50 milliseconds every pulse, its stored voltage level will increase linearly in fixed steps. Components Q11 and R19 (*Calibrate*) supply C7 with a constant current discharge path. Capacitor C7 converts linear pulses to specific voltage levels during each 50 millisecond period. Transistor Q11 also serves as an emitter follower for the meter circuit.

Transistor Q9 is the current source for light bulb L1. Both sources (Q9 and Q10) use zener D10 as their current reference.

Building the Cardio-Tach. The circuit was built on a piece of 2 x 6½-in. perf. board. Mount the perf board assembly via ¾-in. stand-offs to the base of the box. Lead dress and length is not critical.

Next step is to change the meter face. The specified meter has a plastic snap-on cover. Pry it off and cement the new meter face over the original one. As an alternate method, you can cut an adhesive-backed mailing label to cover only the numbers on the original dial scale. Leave the scale division lines visible. The full-scale marking is labelled 150, while

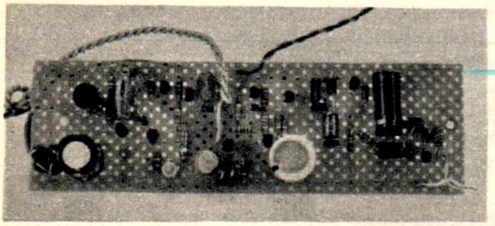

Fig. 1—Prototype's perfboard layout is spacious. Layout can be compressed for more compact unit.

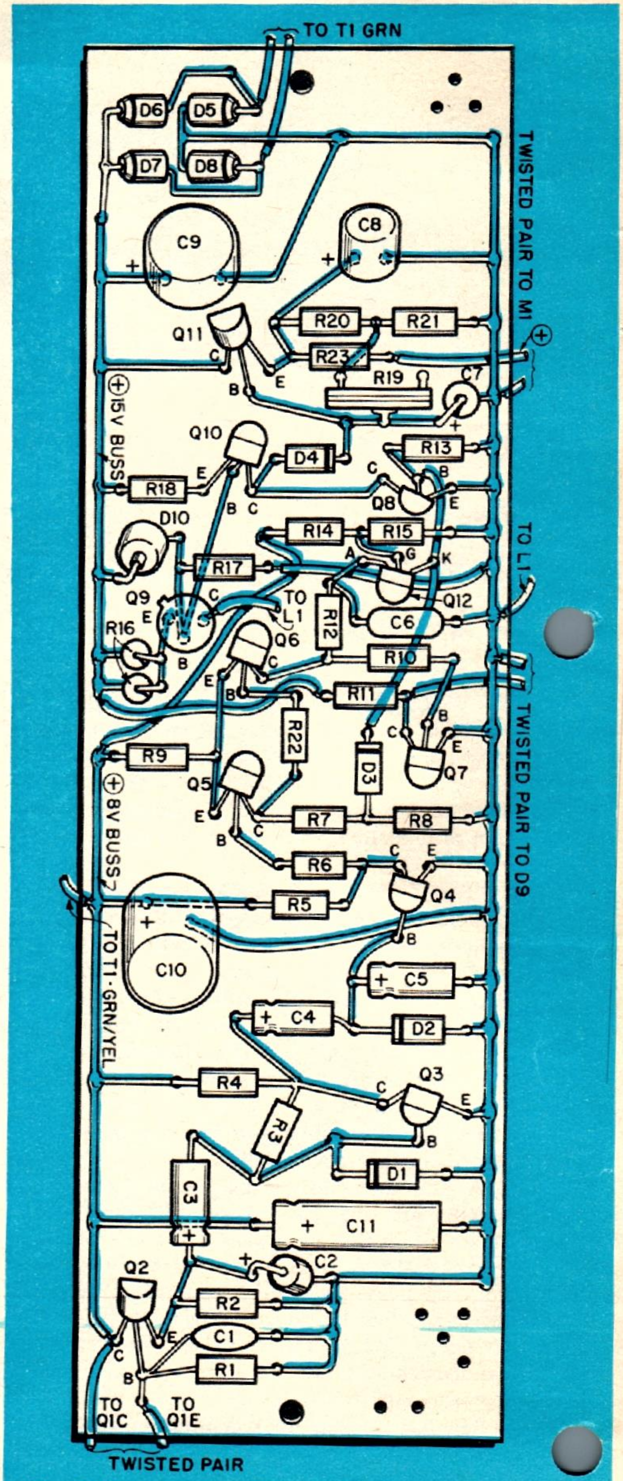

Fig. 2—Layout of cardio-tach. Leads shown in color are beneath perfboard. Clear plastic tubing was used to insulate crossed wires under board.

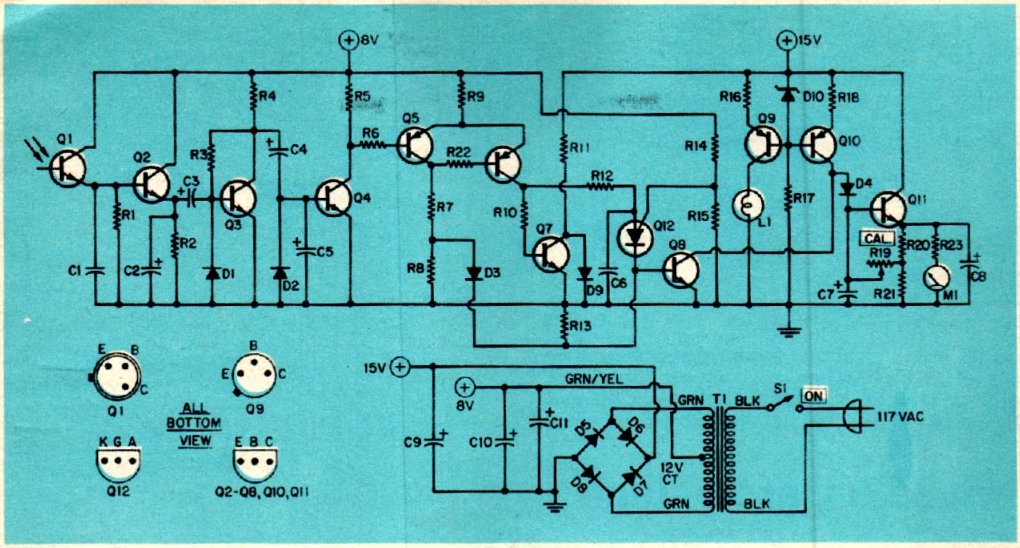

Fig. 3—Schematic of cardio-tach. Be sure to observe proper electrolytic capacitor polarity. Make no substitution for tantalum capacitor C7.

the five remaining segments are marked to read 0, 30, 60, 90 and 120.

Light source L1 and photo transistor Q1 were mounted in a plastic block measuring 1⅛ x ¾ x ½-in. Drill two ¼-in. holes into the block. Hole centers for L1 and Q1 should be spaced ⅝-in. apart. See our pictorial.

Since the photo transistor has a lip on the bottom, we slipped a ⅛-in. piece of plastic tubing over Q1. This shims Q1 snugly in its mounting hole. Place Q1 into the plastic block so that its lens is slightly raised. When you place your finger on the block, the lens is gently embedded into the flesh. Coat the outer surface of the tubing with epoxy before finally slipping it into the block.

Bulb L1 does not require a socket. Wires are soldered to L1's flange and center terminal. Push the bulb into the hole so that its top surface is flush with the top of the block. A drop of epoxy holds the bulb in place. The block is finally mounted to the front panel with a No. 6 screw or epoxy.

Calibration. The easiest way to calibrate M1 is to measure your pulse rate over a one minute time span. Then place your finger on the plastic block and adjust R19 until M1 reads your pulse rate.

A more accurate calibration method can be made with a phono turntable. Solder a pair of extension wires to Q1 and L1. Place an old LP on your turntable and stick a piece of white masking tape on the outer edge of

PARTS LIST

Capacitors: 15 V electrolytic unless otherwise noted
C1—.01 µf, 50 V disc ceramic capacitor
C2-C5—10 µf
C6—.1 µf, 50 V disc ceramic capacitor
C7—3.9 µf, 35 V tantalum capacitor (Allied Industrial Electronics No. 926-0335 $1.15)
C8—50 µf   C9—500 µf
C10—1100 µf, 12 V electrolytic
C11—200 µf, 10 V electrolytic
D1-D3—1N2069 diode
D4—Silicon general-purpose rectifier: 1,000 PIV @ 2.5 A (Motorola HEP-170 or equiv.)
D5-D8—Motorola HEP-156
D9—Light emitting diode (Motorola HEP-P2000 or equiv.)
D10—1N1519 zener diode
L1—6 V @ .04 A lamp (Chicago Miniature 345 or equiv.)
M1—0-50 µa DC microammeter (Calectro D1-910 or equiv.)
Q1—Photo transistor (Motorola HEP-P0001 or equiv.)
Q2-4, Q11—Npn transistor (Motorola MPS 3694)
Q5,Q6—Pnp transistor (Motorola MPS 3702)
Q7,Q8—Npn transistor (Motorola 2N4401)
Q9—Pnp transistor (RCA 40406)
Q10—Pnp transistor (2N4403 or equiv.)
Resistors: ¼ watt, 10% unless otherwise noted
R1—560,000 ohms
R2,R13—4,700 ohms   R3—680,000 ohms
R4—15,000 ohms, 5%   R5—39,000 ohms
R6,R10—12,000 ohms   R7,R8—6,800 ohms
R9—1,000 ohms   R11—1,500 ohms
R12—8,200 ohms   R14,R15—82,000 ohms
R16—75 ohms, 1 watt (2 x 150 ohms, ½-watt)
R17—1,200 ohms, ½ watt
R18—390 ohms
R19—1,000,000-ohms, linear-taper pot.
R20—10,000 ohms   R21—47,000 ohms
R22—68,000 ohms   R23—150,000 ohms
S1—SPST switch
T1—Power transformer; secondary: 12.6 V CT @ 0.1 A (Calectro D1-750 or equiv.)
Misc.—Perforated board, AC line cord.
Note: Cabinet available from Selex Corp., 61 Grove St., New York, N.Y. 10014. Order part No. 30408-P $3.40 plus postage.

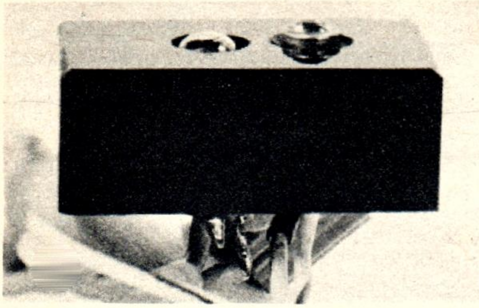

Fig. 4—Photo of plastic block, above. Note how lens of Q1 just clears top surface. Dimensions of block at right. Block material is black opaque plastic. Base lead of Q1 is cut off at case.

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the phonograph record.

Cover about 2-in. of the outer rim. Give the record a half-turn and stick another 2-in. piece of tape on the opposite edge of the record. The two pieces of tape are opposite each other.

Switch on the turntable and set the speed for 33⅓ rpm. Turn the pulse counter on and place the pickup block over the record about ½-in. above the record's surface and just past its edge. Position the photo pickup so that it can see the masking tape as it goes by. Light emitting diode D9 should start to blink every time a piece of tape goes by.

Adjust R 19 until the meter reads 67 Pulses Per Minute. A drop of cement holds R19's calibration in place.

When placing your finger on the pickup block, lay your finger flat on it so that the fleshy pad completely covers both Q1's lens and L1. Do *not* press down hard since this will cut off blood circulation in the area.

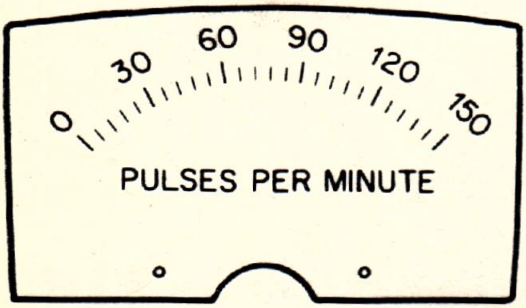
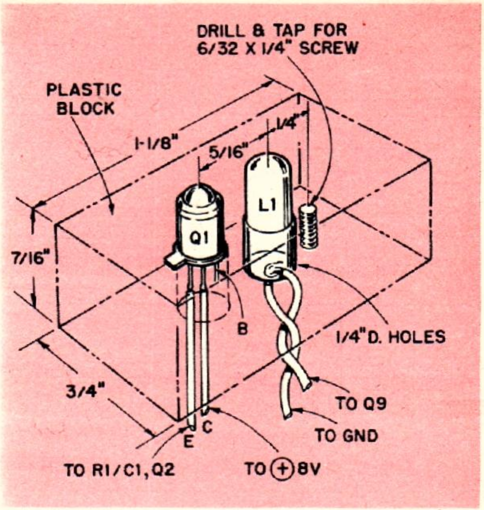


Fig. 5—Cut out or trace dial onto M1. See text.



What does heart rate mean?

A normal heart rate may be anywhere from 60 to 90 beats per minute at rest. Generally, a lower heart rate means that a person is in better than average condition. A stronger heart can pump a larger volume of blood in one stroke, allowing the heart to work at a lower rate.

If you think of your body as a bio-electronic mechanism, the heart is part of a servo loop whose function is to use the blood to carry oxygen from the lungs to body tissues. As stroke volume increases, heart beats-per-minute decrease in order to keep the rate of blood flow constant.

Recently, a great deal of interest has developed around the scientific study of physical fitness. It has been found that if the heart rate can be brought up to 140 beats per minute for several minutes a day, your heart, lungs, and overall muscle tone will start to improve. The best exercises to accomplish this are running, jogging and swimming.

For a man in poor physical condition, any mild exertion may raise his pulse rate from 90 p.p.m. at rest to 140 p.p.m. If he exercises on a regular basis, it will take more strenuous exercise to raise his heart rate to this higher level.

Some athletes have heart rates as low as 40 beats per minute at rest.

Point is, if you can bring your heart rate up to 140 beats per minute, you're doing the right amount of exercise. But too much exercise will force your heart rate to continue to rise. Don't let it exceed 160 p.p.m. for *any* length of time, unless you're in excellent condition or a trained athlete. In any case, an exercise program should be under the supervision of your family doctor.