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easy-to-build Transistor Projects

ANYONE CAN BUILD THESE 10 AMUSING DEVICES:

- The Radiomobile
- Lemon-Juice Oscillator
- Sherlock Ohms
- Electronic Eyeball
- Home Broadcaster
- Musical Oatmeal Box
- The Flip-Flop
- Toddlers Tooter
- The Radio-Clock
- "Boris" the Talking Skull

easy-to-build

Transistor Projects

by Len Buckwalter

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EASY-TO-BUILD
TRANSISTOR PROJECTS

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PREFACE

Meet Boris the talking skull, Sherlock Ohms the electronic detective, and a singing oatmeal box. These are just a few of the characters which prove that transistors can really be fun.

If some of the projects described in this book look suspiciously practical, they are. The magic of putting the human voice over the air (as in the home broadcaster) never seems to lose its fascination for electronics hobbyists. The flip-flop circuit described can be used very effectively as a metronome or as a timer for other activities. The radio clock (different from a clock radio) is a useful as well as an ornamental gadget.

So all you need is the desire to create the useful, the amazing, or the weird to experience many enjoyable hours with transistor circuits. No knowledge of ohms, volts, or amps is required.

For those who can't suppress their more serious side, a brief explanation of the theory is provided at the end of each project.

LEN BUCKWALTER

CONTENTS

CHAPTER 1

CONSTRUCTION HINTS

Although electronic circuits must often be built to the most exacting standards, there's plenty of room for variation in the projects described in this book. They permit the builder to use parts he has on hand or can obtain easily. The following section shows where liberties may be taken with parts and assembly—and when it's a good idea to follow the text closely.

PARTS

Don't overlook the numerous sources for parts that are easily accessible to the electronic hobbyist. You may not have the legendary "junk box" which can yield every component needed, but old discarded radio and TV sets are often rich sources for resistors and capacitors. If your home doesn't harbor one of these antiques, a few inquiries among friends might provide a windfall. You'll find that many of the components in the Parts List for the projects have the same values as the components commonly found in home-entertainment equipment.

There is a small risk involved with old parts, but one that can be reduced considerably if you have an ohmmeter. Both resistors and capacitors can be checked with it. The meter indicates resistance directly. It also gives a fair test of capacitors. Place the meter on its highest resistance range and touch the probes across the capacitor.

If the meter moves more than halfway down the scale and remains there, reject the part. Serviceable capacitors cause only a brief movement of the meter needle.

Electrolytic capacitors (the ones marked "plus" and "minus") can produce low-resistance readings and still be good. However, if they read less than 30,000 ohms after the probes have touched them for more than a minute, it's best to reject them.

Those who want to use entirely new components will find them at many electronic parts distributors. This source also must be relied on for more specialized units like a photocell or transistor battery.

Here are some suggestions on each of the major components that recur throughout:

RESISTORS

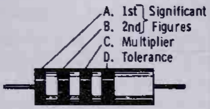
The sharp-eyed hobbyist will spot the use of large-wattage resistors in some of the photos, even though ½-watt units are specified in the Parts Lists. This is perfectly acceptable—1- or 2-watt resistors will not affect circuit operation unless you want the tiny ½-watter for miniaturization.

It's the value in ohms that counts, and even it may vary as much as 20% from the recommended value. The only critical circuits from the standpoint of resistance are in the base-bias system of the transistor. This resistor is easily recognized on the schematic. Look for the one that connects the base lead to the negative side of the battery. Anytime a project refuses to work, be sure the base resistor is the value specified.

RESISTOR COLOR CODES

Resistors, perhaps more than any other single electronic component, depend on color coding to indicate their values. The four-band color-coding system shown in Fig. 1-1 is in almost universal use today. The color of the first band (labeled A) gives the first significant figure of the resistance value. The color of the second band (labeled B) gives the second significant figure. The color of the third band (C) is the decimal multiplier or the number of zeros to be added to the first two significant figures in order to determine the total value of the unit. The fourth

COLOR BAND SYSTEM



Resistors With Black Body Color Are Composition, Non Insulated.
Resistors With Colored Bodies Are Composition, Insulated.
Wire Wound Resistors Have The 1st Digit Color Band Double Width.

RESISTOR CODES (RESISTANCE GIVEN IN OHMS)

COLOR	DIGIT	MULTIPLIER	TOLERANCE
BLACK	0	1	±20%
BROWN	1	10	±1%
RED	2	100	±2%
ORANGE	3	1000	±3% •
YELLOW	4	10000	GMV•
GREEN	5	100000	±5% (EIA Alternate)
BLUE	6	1000000	±6% •
VIOLET	7	10000000	±12 1/2%•
GRAY	8	.01 (EIA Alternate)	±30% •
WHITE	9	.1 (EIA Alternate)	±10% (EIA Alternate)
GOLD		.1 (JAN and EIA Preferred)	±5% (JAN & EIA Preferred)
SILVER		.01 (JAN and EIA Preferred)	±10% (JAN & EIA Preferred)
NO COLOR			±20%

•GMV = guaranteed minimum value, or -0 + 100% tolerance.
±3, 6, 12 1/2, and 30% are ASA 40, 20, 10, and 5 step tolerances.

Fig. 1-1. Resistor color codes.

band is concerned with resistor tolerance; three values are possible. A gold band indicates a resistive tolerance of ±5% of the value of the resistor. A silver band represents a resistance tolerance of ±10%, and when no fourth band is present, the resistive tolerance is ±20% of this value.

The placement of the four bands on the body of the resistor does not pose any particular problem in identifying the first color, since the tolerance band is either absent, or it is gold or silver. Gold and silver are used because neither is similar to any other color employed in the other three bands.

The following two examples will indicate how the color-coding system operates.

Example No. 1

Consider a resistor on which band A has the color green to represent the first figure of 5, band B has the color black to represent the second figure of 0, band C has the color yellow to indicate that four zeros are to be added, and there is no tolerance band. By putting the information obtained from these figures together, you obtain the resistor value of 500,000 ohms. The lack of a tolerance band on this resistor indicates that the tolerance figure is ±20% of this value of 500,000 ohms.

Example No. 2

Band A is violet, band B is green, band C is brown, and band D is silver. By putting these figures together the result is a value of 750 ohms with a tolerance of ±10%.

Tolerance, the fourth band of the resistor color code, may be any standard value. It makes no difference in these projects whether the resistor is identified with a gold or silver marking or none at all.

CAPACITORS

The Parts Lists do not give the voltage rating for capacitors unless they are electrolytics. The reason is that if you purchase a capacitor rated at 15 volts (the working voltage in virtually all these circuits), its cost would be inordinately high. More standard units are suitable, although their ratings may be several hundred volts. What is more important is the capacity, or value in mfd.

Electrolytics do just the opposite: they increase in price with voltage rating. However, a 150-volt unit, say from an old radio, can be used even though a 15-volt capacitor is specified.

BATTERIES

Batteries are another area where variation is permissible. The current consumption of most projects is less than 5 or 6 milliamperes. Any conventional transistor battery of the nominal 9 volts will last many months. Avoid any units which are less than half the physical size of those shown in the photos.

It's possible to hook a group of flashlight batteries together for more power or voltage. Six of them connected in series (plus to minus) can produce 9 volts. The governing factor is physical size. The transistor battery makes possible a trim, easy-to-move-about project.

You can solder directly to the terminals of a battery, or use matching clips. The key advantage of clips is that a single battery can be conveniently used for a number of projects.

WIRE

The usual hookup wire is No. 20 or 22 solid tinned copper with plastic or cotton insulation. Any lead that will undergo repeated flexing is less likely to break if it is of the stranded type. It can also be employed throughout most of the circuit; but solid wire is much easier to crimp onto a solder lug or terminal strip.

Enamel-covered wire (used for making coils) is often listed under the catalog heading of magnet wire. The chief precaution in using it is to scrape the enamel off the end being soldered. This may be done with a knife if you're careful not to nick and thereby weaken the wire. A single-edge razor blade does a better job. For really professional results, buy a small bottle of *Strip-X*. Simply dip the end of the wire into it, and wipe off the enamel with a cloth a minute or two later. Whatever method you use bright copper must show before the wire will accept solder.

Where stiff wire is called for, ask for "piano" wire at a model-airplane or hobby store.

TRANSISTORS

One key to success with transistors is correct hookup of their three leads into the circuit. You don't have to take great pains to avoid overheating their leads while soldering; tests show that little damage results from a hot iron.

Unless you're certain which transistor leads are the base, emitter, and collector, refer to Fig. 1-2. In the pictorial drawings for each chapter, they are lettered *B*, *E*, and *C*. Always take great care to insert them into their proper circuit locations.

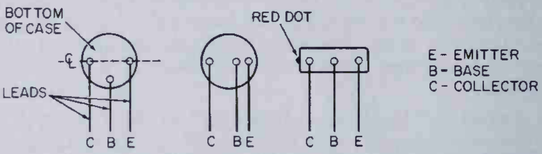


Fig. 1-2. How to identify transistor leads.

All transistors used in the projects are of the common pnp type, though their lead arrangement will vary. If you are a bargain hunter, watch the electronic distributors for their frequent transistor sales slanted to experimenters and hobbyists. Many of these units are unmarked except for the simple designation "pnp, General-Purpose Audio." The author has used dozens of these in the construction of the projects with success.

COILS

There is a single coil that frequently appears in the various projects. It is used when the circuit operates on radio frequencies. Although designed for transistor receivers, it performs perfectly well in oscillators. The coil is variously marketed as a "tapped antenna coil" or "transistor loopstick" for the standard broadcast band. These units generally have three lugs for connection into the circuit. To identify them, use the diagram customarily supplied in the coil box. Then compare it with the schematic of the coil in the project you're building. The three connections must agree or the circuit won't work. The most important identifying feature is the coil tap; it is closer to one end of the coil than the other.

CHASSIS

In an effort to avoid extensive metalwork, much use is made of circuit boards. Fig. 1-3 illustrates some typical

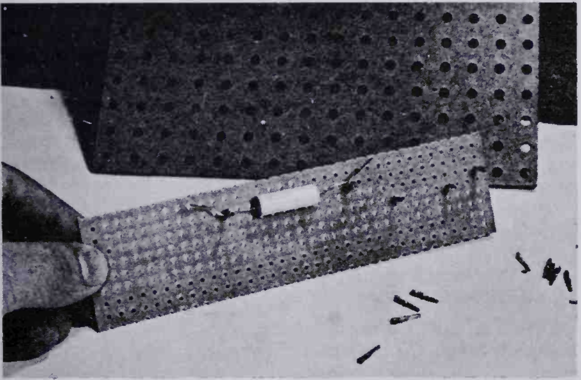


Fig. 1-3. Types of boards to use.

kinds. Perforated board of phenolic is a standard electronics item. Small holes punched in it permit the use of *flea clips,* or push-in terminals, as circuit solder and tie points. The clips are easily pushed into a hole at any desired location.

Solid hardboard and pegboard are also handy for construction. The latter type is especially useful since nuts and bolts are readily mounted in the holes. Because no high frequencies are involved, circuit layout on these boards is not critical. And they have sufficient insulating qualities so bare wires may touch their surfaces without the problem of shorts.

STARTING A PROJECT

Before starting construction, it is a good idea to first read the complete chapter. Each is divided into sections which describe the nature of the device, how it operates, and the connection steps. Wherever necessary, a Parts List is provided.

Nearly all the parts are available from local suppliers or through the catalogs of the large mail-order houses which cater to the electronic hobbyist. These catalogs are usually sent free of charge on request. (Addresses can be found in electronic magazines sold on the newsstands.) Parts of a nonelectronic nature, such as a strip of metal, are household items or are available in local hardware stores.

Wiring a project can be done by using the illustrations provided. If the reader has had no previous experience in electronics, the pictorial wiring guide (where actual parts and wires are shown) should prove the most useful. In each case, however, the schematic diagram is also shown. A surprising amount of information may be gleaned from the schematic by comparing it with the pictorial. In some instances, the schematic provides a clearer picture of certain wiring connections in a project.

SOLDERING

Whether you use a soldering iron or gun, there are several things to observe while soldering. Use *rosin* core solder (never acid core). A clean connection is important; remove any dirt or grease where solder is to be applied. The iron tip should be free of scale or corrosion. Clean it with a file or steel wool, then tin it with a coating of solder. Wipe off excess solder from the tip with a heavy rag.

As shown in Fig. 1-4, the iron is applied to the joint or connection to be soldered. A common error in soldering is touching solder to the hot tip of the iron, causing it to run over the surface of the joint. This frequently forms a poor, powdery blob known as the "cold-solder" joint. The correct technique is to heat the joint and parts to be

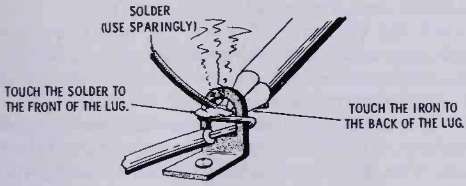


Fig. 1-4. Touch solder to the heated joint, not to the iron.

soldered. The solder is then touched to the parts for melting. The best result occurs if the solder flows into all crevices of the connection and the joint cools with a shiny, ribbed appearance. Use just enough heat to melt the solder and cause it to be drawn into the heated connection.

TROUBLESHOOTING

The best kind of troubleshooting is done as the project is being constructed. All connections should be carefully checked at least twice for error during assembly. Some people find it helpful to check off completed connections in pencil directly on the diagram. This provides a running record of parts and wires that have been installed. If difficulty is experienced in the completed model, consider these suggestions:

1. Have someone else check your connections. Frequently, one person is likely to overlook an error more than once.
2. Are components installed correctly? Transistors, electrolytic capacitors, and other parts may be installed in only one direction; reversing their leads could cause burnout or faulty operation of the circuit.
3. Power polarity is also critical. Be certain that the positive lead, for example, does in fact go to the positive power source.
4. Check for presence of power. If no meter is available, any small bulb designed to operate at the voltage level you are using can be the indicator. Connect it to the power source to see if the bulb lights.
5. Recheck solder joints. It is possible that beneath the surface of a solder joint there is poor electrical contact. This may usually be detected by grasping each wire and moving it slightly to restore continuity. If the joint is defective, resolder it.
6. Short circuits. All bare wires or parts, unless shown otherwise, must not make contact with each other.

CHAPTER 2

THE RADIOMOBILE

Looking like a cross between a piece of modern art and the day the radio fell apart, the Radiomobile is guaranteed to stimulate a lot of living-room conversation. This eerie project was inspired by the artist's mobile—the ghostly assembly that forms changing patterns as it is nudged by air currents. Fig. 2-1 shows a mobile—only the parts are all electronic and are fashioned in such a way that a radio

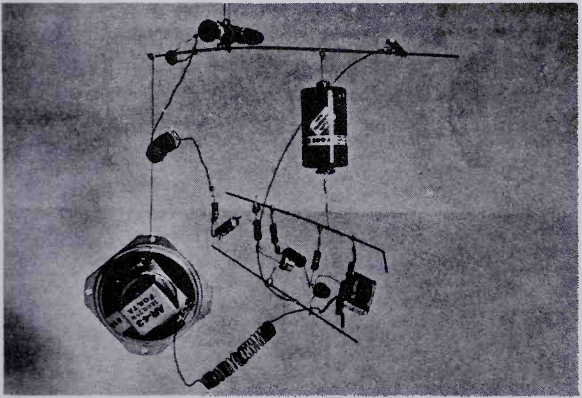


Fig. 2-1. The completed radio mobile.

program is heard from the speaker! It plays as the unit swings from its perch, which can be a bookcase or wall. If you decide to construct the project, you too can express an artistic inclination. The model may be followed exactly as shown, or varied in countless ways using the same basic parts and building techniques.

The simplicity of the circuit makes it easy to construct but does limit its performance. The radio plays best if there is a strong local station nearby, since reception on distant stations is weak. However, this has not proved to be a serious drawback. Many people, on first seeing the Radiomobile, doubt that it is more than a novel decoration. Their expression soon changes when it is turned on and they are told to listen.

CONSTRUCTION

The best place to begin construction is on the framework that holds the two transistors (Figs. 2-2 and 2-3). Place two stiff wires on the worktable and position them as shown in the drawing. Within this framework you can connect the small parts into their approximate locations before soldering. Using the two transistors and transformer T1 as the main guides, resistors and capacitors

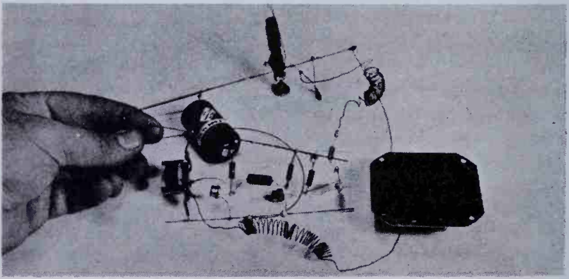


Fig. 2-2. Construction details.

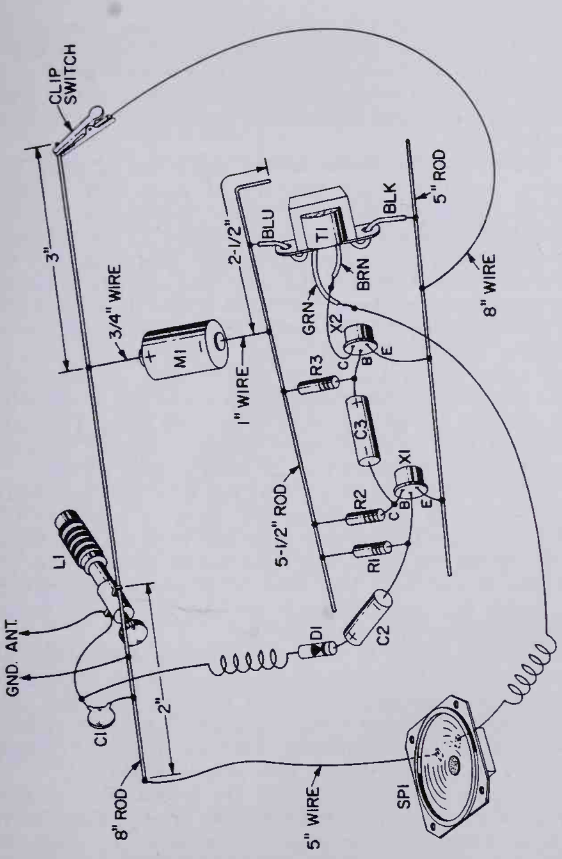


Fig. 2-3. Pictorial diagram.

may be fitted into the spaces between them. Once you're sure there's room for everything, cut the leads to length on the various parts and crimp them to each other with pliers. Next the joints are soldered in one operation. This forms a rigid assembly that may be lifted off the tabletop in one piece.

Watch out for shorts during this stage of assembly. Look over the circuit carefully, to make sure no bare wires accidentally touch each other. Notice, too, that the blue and black wires from transformer T1 are threaded through the holes in the transformer mounting tabs. Do not solder these leads to the tabs; they act only as guides to keep the transformer positioned within the framework. The transformer leads fasten to the upper and lower lengths of stiff wire. All wiring—except for the leads on the components, and pieces of stiff wire—is done with No. 28 enamel-covered wire. Any time an end of this wire is soldered, the enamel must be scraped away. This may be done with a knife, razor blade, or enamel remover until about one-fourth inch of shiny copper shows.

Now for the other wires that run from the framework to the rest of the Radiomobile. Hook in capacitor C2, diode D1, and the spiral of wire that runs to the antenna coil. Install the 8-inch wire that has an alligator clip attached to one end. Two more leads run to the battery negative terminal, and from the blue wire of the transformer to one of the speaker lugs.

The two spirals of wire visible in the illustrations do not appear in the schematic, since they do not act as electrical coils. Instead they serve to make electrical connections and do impart some springiness between various sections of the Radiomobile. Between 30 and 40 turns, wound on a pencil, should give proper action.

Continue the assembly with the 8-inch piece of stiff wire which forms the top part of the project. First insert the wire into one of the lugs of antenna coil L1. Slide the lug about two inches from one end of the wire, and secure it with solder. The antenna coil used here is the standard loopstick used for broadcast receivers; and in this model is a transistor type having three lugs. (The middle lug is not used.) However, any loopstick for the broadcast band and of the same general dimensions can be used. If it is designed for a tube radio, simply use the two lugs provided. Just be sure it has a tunable core and an adjustable knob.

The 8-inch wire is completed by soldering capacitor C1 in place, and also the wires for the speaker and battery. Both battery wires are soldered to the end terminals of the battery. Try to center them as closely as possible so the battery will hang vertically.

The next phase of construction is balancing. Attach both ground and antenna leads to the points indicated, using about a 6-foot length for the ground wire and 30 or more feet for the antenna. Both leads are cut from the same No. 28 enamel wire used previously for wiring. About six inches above the antenna coil, wind the two wires around an anchor point. (This may be an arm formed from a piece of coat hanger.) At this time you should have the 8-inch stiff wire in front of you, suspended above the table. Fasten the speaker lead to one end of the wire and the lead from the positive terminal of the battery near the opposite end. The basic method of balancing is to slide the positive battery connection back and forth over the stiff wire. Once you find the point at which the stiff wire remains near the horizontal position, solder the battery wire to it.

The Radiomobile will be most interesting to view if you adjust the various sections—speaker, framework, etc.—so they lie in different planes. Some judicious bending can take care of this.

OPERATION

Choose a location that enables you to mount the unit at about eye level. The coat-hanger arm can be slid under some books or fastened to a wall. It is a good idea to pick a spot near a wall outlet, even though you don't need a-c power for the unit. The outlet affords a convenient hookup for the ground wire—loosen the screw that holds the a-c outlet cover plate and secure the ground wire to it. Again, it is necessary to scrape away some enamel insulation for good contact.

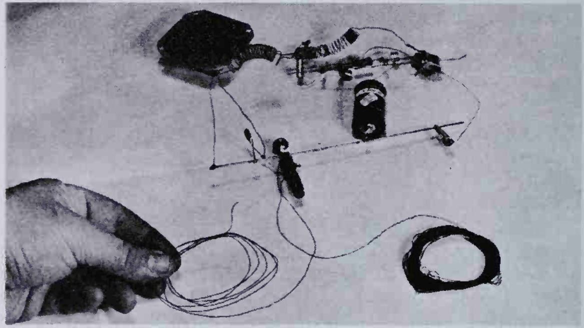


Fig. 2-4. Showing the antenna.

The antenna shown in Fig. 2-4 is strung out for its full length of 30 or more feet. (Its small diameter permits it to be easily hidden.) If you are some distance above ground, the antenna may be hung out a window.

The performance of the circuit depends greatly on the distance from the radio station. Power is applied by hooking the alligator clip to the top wire of the assembly (see Fig. 2-5). With your ear next to the speaker, start turning the knob on the antenna coil. It's important that the knob turn easily, or the complete Radiomobile will rotate with it. Any stiffness or binding can be eliminated by slightly prying apart the metal slits into which the tuning shaft is threaded (be very careful not to break them).

Strong local stations should develop enough volume to be heard several feet from the speaker. More distant

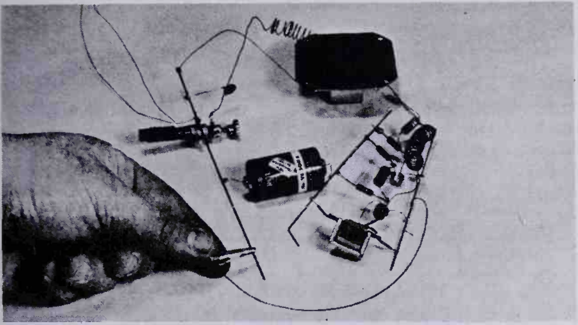


Fig. 2-5. Completing the circuit.

stations require closer listening. Because of differences between models, your Radiomobile may not tune-in the complete broadcast band, but may favor the upper half of it. If you are unable to tune-in local stations below approximately 700 kc, try replacing C1 with a capacitor in the 330-pf range.

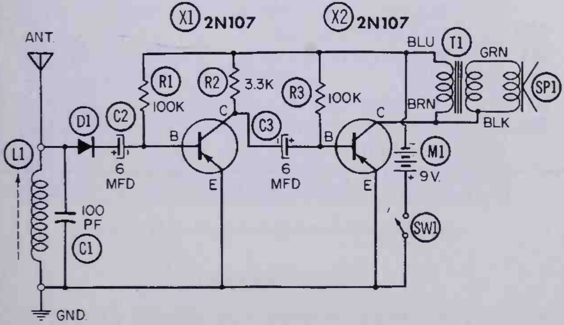


Fig. 2-6. Schematic diagram.

ABOUT THE CIRCUIT

The Radiomobile selects stations by means of tuned circuit L1-C1 (Fig. 2-6). The audio frequencies are removed from the radio wave by diode D1 and are amplified by the two transistors. The speaker reproduces the audio frequencies as sound.

PARTS LIST

Item No.	*Description*
R1, R3	100K, ½-watt resistor.
R2	3.3K, ½-watt resistor.
C1	100-pf disc ceramic capacitor.
C2, C3	6-mfd miniature electrolytic capacitors, 15-volt.
L1	Loopstick antenna coil (broadcast type) with knob (Superex VLT-240 or equivalent).
D1	Germanium diode, 1N34.
X1, X2	2N107 transistors.
T1	Miniature transistor audio-output transformer. (400 ohms to voice coil).
SP1	Speaker, 2½-inch.
M1	9-volt battery (RCA VS-300A, or equivalent).
SW1	Alligator clip for switch.
Misc.	Stiff wire; No. 28 enamel-covered wire; coat hanger.

CHAPTER 3

LEMON-JUICE OSCILLATOR

The large object in the foreground of Fig. 3-1 is not a new type of electronic component—it's half a lemon! Combined with a transistor circuit that can produce a tone, the juice of this fruit supplies the raw material for a working battery!

It's a surprising demonstration that begins when someone holds the headphone to his ear and you touch the penny to the lemon. A tone is heard each time the penny makes contact.

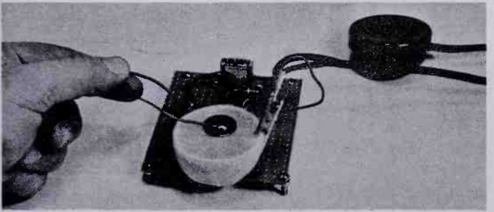


Fig. 3-1. The completed lemon-juice oscillator.

CONSTRUCTION

The project is built on a piece of electronic pegboard (see Fig. 3-2). The four legs of the board are ½-inch screws inserted into the holes and fastened by nuts. Fig. 3-2 also illustrates the use of small "flea" clips to support the main parts of the circuit. Six of them are pushed into holes. The transformer is mounted next. Use small nuts and screws to hold the two mounting tabs to the board. Two red and blue wires, if your transformer is color-coded this way, face toward the rear edge of the board. Hook the transistor and resistor to the correct clips, and begin soldering the circuit together. The head-

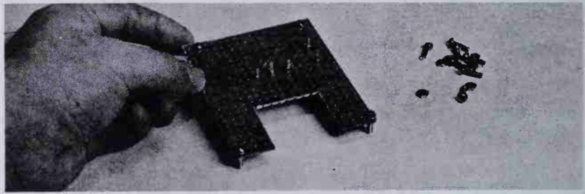


Fig. 3-2. Board with legs mounted.

phone tips can be soldered directly to the board clips. Don't remove these tips since they hold solder easier than the headphone wires.

Your transformer may not have the same color coding shown in the drawings. In this instance, the correct connections aren't difficult to figure out. Assuming you have purchased the transistor driver transformer specified in the Parts List, it will have two sets of leads. The secondary (rated at 2K, or 2000 ohms) usually has three leads. Checking the information supplied with your transformer, connect one secondary wire to the emitter (E) of the transistor (Figs. 3-3 and 3-4) and the other to the lead that goes to the penny. (Do not use the center-tap wire, if the secondary has one.) The primary of the transformer is the 10K side. Its two leads connect to the transistor collector (C) and to the wire with the alligator clip. Important: If your transformer does not have the color coding of the model described here, the circuit may

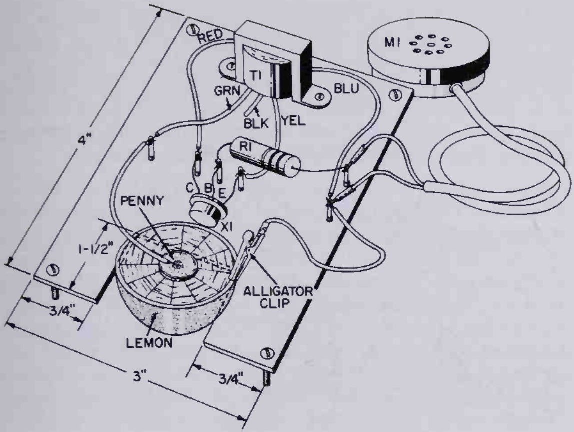


Fig. 3-3. Pictorial diagram.

fail to produce a tone after it has been wired in. If this occurs, simply reverse the two secondary wires (yellow and green in the drawing).

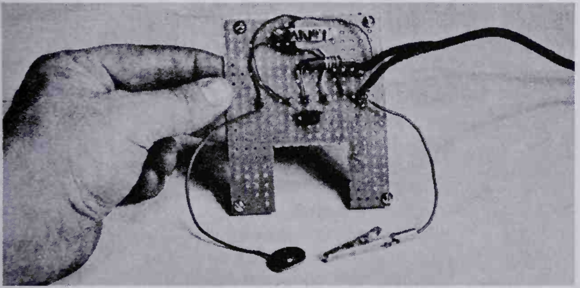


Fig. 3-4. Construction details.

As also shown in Fig. 3-5, the two wires going to the lemon are terminated with an alligator clip and a penny. If you clean the penny with a piece of steel wool, there should be little difficulty in soldering the wire directly to it. Be sure the alligator clip is not the copper-colored kind. Pure copper clips will not permit the unit to operate because they interfere with the battery action.

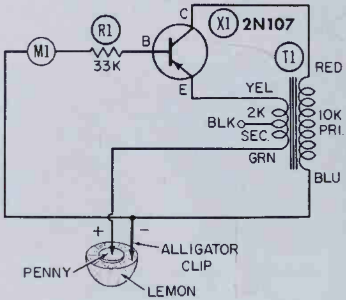


Fig. 3-5. Schematic diagram.

OPERATION

Half of a lemon is shown in Fig. 3-1, but a much smaller piece will power the oscillator. Place it in the notched section of the board. First, press open the alligator clips so one jaw bites into the lemon while the other jaw clamps to the outer skin. Next, press the penny firmly onto the lemon while listening in the headphone. Move it slowly toward the alligator clip until the tone is heard. There must be some separation between the clip and penny, or the battery won't work. Often, the lemon must be squeezed slightly (watch your eye) in order for juice to flow between the penny and clip, and start the tone.

After the unit is operated for a while, the tone may disappear. Remove the clip and penny, and wipe them briskly with a piece of cloth. The single piece of lemon should last a fairly long time, even after it looks dried out. In the model, the oscillator worked although the lemon was left on a worktable for more than a week. Of course you can preserve your lemon battery by wrapping it to keep in moisture and storing it in your refrigerator.

ABOUT THE CIRCUIT

The citric acid in the lemon starts a chemical reaction that produces electricity. Although only a few thousandths of a watt, the current is enough to trigger the transistor circuit. When the juice contacts the metal of the alligator clip, invisible particles known as ions begin to dissolve. This electrically unbalances the metal and it becomes negatively charged. The penny is not so affected by the lemon. Compared to the clip it becomes positively charged and electrons flow from the clip, through the transistor oscillator circuit and then back into the battery.

Electrical action is similar to that of an actual battery. Hence, if you have trouble making the oscillator work, try hooking in a regular 1.5-volt flashlight battery temporarily. The penny is touched to the positive, or button end, and the alligator clip to the negative end. You can return to the lemon battery after correcting any errors you may have made during construction.

PARTS LIST

Item No.	*Description*
R1	33K, ½-watt resistor.
X1	2N107 transistor.
T1	Transistor driver transformer, miniature type, 2K to 10K.
M1	Headphone, dynamic type, 1K.
Misc.	3″ × 4″ perforated board; four ½-inch screws; hookup wire; flea clips; alligator clip; penny; lemon.

CHAPTER 4

SHERLOCK OHMS

If you've ever wanted to play amateur detective, a valuable addition to your bag of tricks is the electronic "bug" shown in Fig. 4-1. With it you become the intrepid "Sherlock Ohms" (a modern-day version of the turn-of-the-century sleuth). Though the original Sherlock relied heavily on powers of deduction, he might have dispatched the villain faster with some electronic aids.

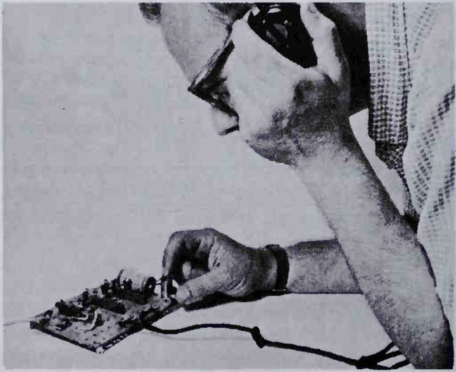


Fig. 4-1. Using the electronic bug.

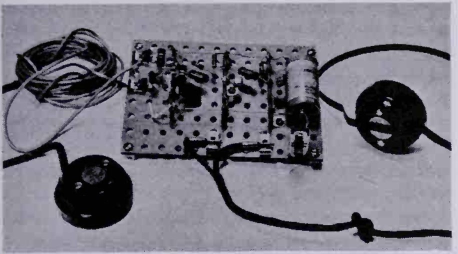


Fig. 4-2. The complete assembly.

The three basic sections of the bug are shown in Fig. 4-2. A circuit board is at the center, with a microphone at the left and an earphone at the right. The coil of wire (15 or more feet) connected to the microphone allows it to be located a considerable distance from the board. Easily hidden, the mike is an electronic eavesdropper sensitive enough to pick up a voice about ten or fifteen feet away.

CONSTRUCTION

A piece of pegboard measuring 6″ × 4″ serves as the chassis (Fig. 4-3). The predrilled holes make this material easy to work with, but solid board is just as satisfactory. Most of the components are arranged on the lugs of three terminal strips. Notice how a common lead of bare wire from the negative battery terminal joins all top lugs, while another length joins the lower ones. After these are installed, the various resistors, capacitors, and transistors are hooked to the terminal lugs and soldered in place. Four Fahnestock clips afford a convenient method for fastening the mike and earphone wires to the board.

As shown in Fig. 4-4 little wiring is done on the underside of the board. The four solder lugs which slip under the screws that hold the Fahnestock clips provide a means

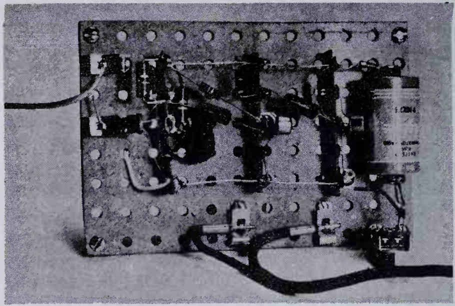


Fig. 4-3. Construction details (top view).

of connecting the four wires which go to the mike and earphone.

The legs are an important part of the construction. These are added to the four corners of the board to prevent any bare wires or contact points from touching a metal surface upon which the board might rest. This

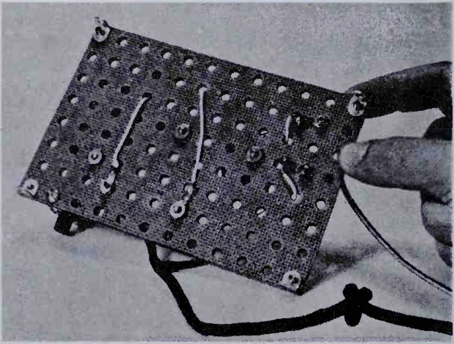


Fig. 4-4. Construction details (bottom view).

could interfere with circuit operation, or short the battery and quickly exhaust its energy. Use four small "L" brackets to keep the bottom of the board about one-half inch above any surface. The legs may be wood strips, or pieces of scrap metal bent into right angles and drilled for mounting screws.

OPERATION

You can make a quick check of the completed project by turning on the power and listening in the earphone. If the circuit is functioning properly, a hum should be heard when you touch a fingertip to the base (B) terminal of the first transistor, X1 (Fig. 4-5).

Next, the microphone cable is slipped into the Fahnestock clips at the left side of the board. Unravel the cable and hide the mike in any desired location. Try not to cover the small holes through which the sound enters.

For best operation, the mike cable should be shielded, as shown in the drawings, to prevent picking up hum radiated by the a-c house wiring. If the cable lengths are only 10 to 15 feet, regular hookup wire will work if the two leads are twisted together tightly. For longer distances, however, a shielded phono cable must be used to prevent hum pickup.

ABOUT THE CIRCUIT

The unit shown in Fig. 4-6 is a three-transistor amplifier. The input is supplied by the microphone, which is actually an earphone that generates an audio voltage when sound strikes it. The three transistors build up this small voltage to a level sufficient for operation of the earphone. No transformers are used since the earphone and microphone are selected to match the transistors on both the input and output sides.

Note that a crystal microphone or regular speaker will not work in this unit; their impedances are not satisfac-

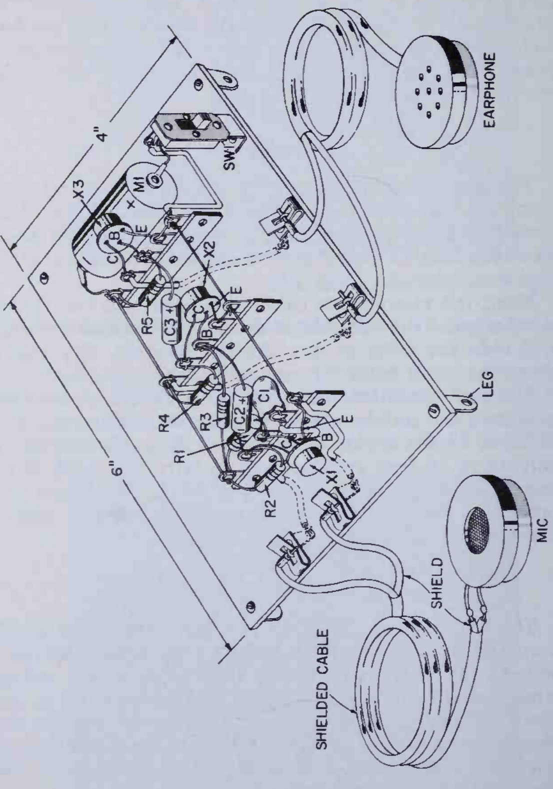


Fig. 4-5. Pictorial diagram.

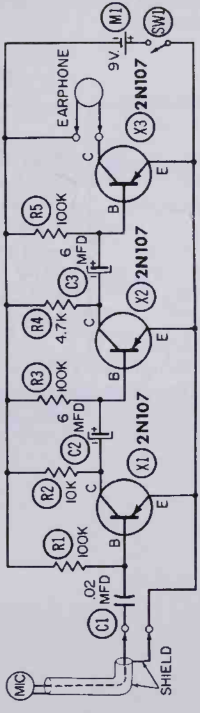


Fig. 4-6. Schematic diagram.

tory for a proper match and amplification will suffer. The Parts List calls for 1000-ohm magnetic earphones, but a certain leeway is permitted here. Devices rated between 1000 and 3000 ohms should not have excessive losses.

As long as the approximate impedances are observed, the microphone may be as small as you wish. In fact, one of the miniature magnetic earphones may be substituted if desired.

PARTS LIST

Item No.	*Description*
R1, R3, R5	100K, ½-watt resistors.
R2	10K, ½-watt resistor.
R4	4.7K, ½-watt resistor.
C1	.02-mfd disc capacitor.
C2, C3	6-mfd electrolytic capacitor, 15-volt.
X1, X2, X3	2N107 transistor.
SW1	Single-pole, single-throw switch.
M1	9-volt battery.
Earphone, microphone	1000-ohm magnetic earphone.
Misc.	Pegboard; shielded phono cable; hookup wire; 4 Fahnestock clips; three 5-lug terminal strips; 4 solder lugs.

CHAPTER 5

ELECTRONIC EYEBALL

Here is an amusing example of how electronics can act as a substitute for a human sense. The fellow in Fig. 5-1 (with the "other-world" eyeballs) is demonstrating a gadget that can actually "see." It works this way: First a

Fig. 5-1. Demonstrating a gadget that can actually see.

room is completely darkened except for a single light source, either a lamp, flashlight, or a window through which outdoor light is shining. A blindfolded person wearing the device is led into the room and, with a searching movement of the head, can find the light source in seconds!

CONSTRUCTION

Assembly begins with the two "eyeballs" made from a single ping-pong ball. Carefully saw the ball in half and then cut a ¼-inch hole in the center of each. A simple method of cutting these holes is to place each half of the ball (hollow side up) on a piece of wood and make four slits in a square with the tip of a screwdriver; then push out the square piece and file the hole into a circle. Only one of the halves receives the photocell, or light-sensing element, but holes are made in both for the sake of appearance. (See Figs. 5-2 and 5-3.)

The photocell is glued into one of the "eyeballs," and two flexible wires about a foot long are soldered to its terminals. Be sure that light can enter the eyeball and fall on the photocell. Both "eyes" are fastened in place on the blindfold by thread or small wire loops. The blindfold itself is cut from a piece of dark cloth measuring 6″ × 36″. It is folded in half lengthwise and the wires from the photocell hidden between the folds.

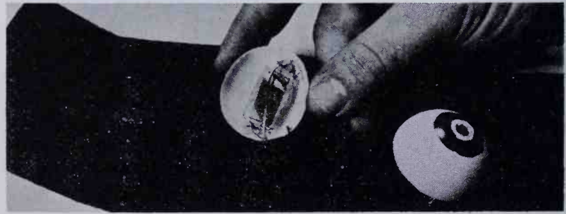


Fig. 5-2. "Eyeball" construction.

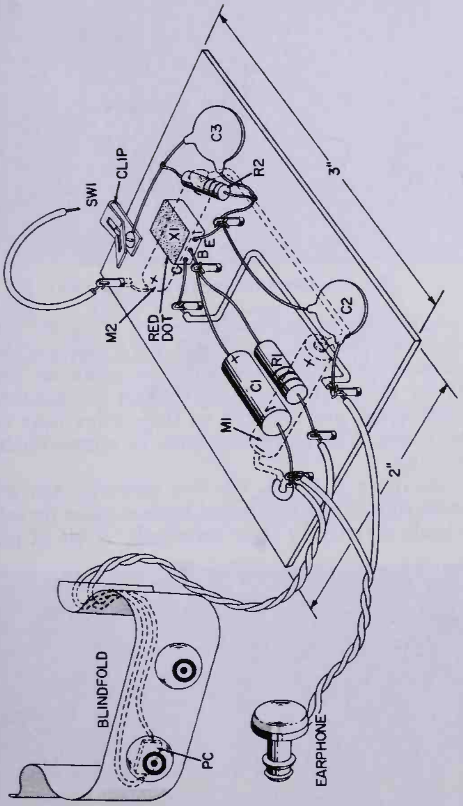


Fig. 5-3. Pictorial diagram of the wiring.

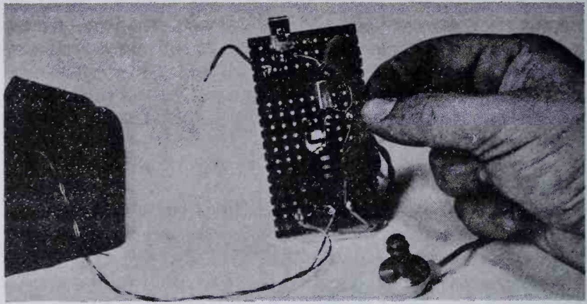


Fig. 5-4. Construction details (top view).

A small piece of perforated board, 3″ × 2″, serves as the electronic chassis. (See Fig. 5-4.) A series of flea clips is inserted into the board holes to serve as mounting points for the components; notice how the earphone and photocell wires are soldered to three clips near one end of the board. The earphone cable is approximately ten inches long.

As shown in Fig. 5-5, the two batteries are wired to the underside of the board and held in place by soldering their leads directly to their terminals. A bit of glue will

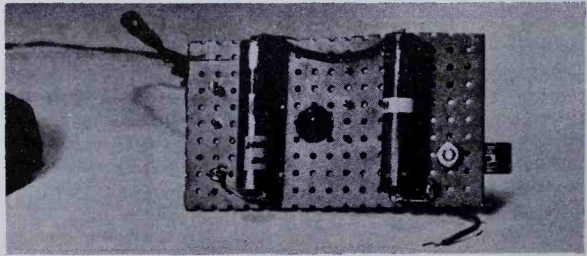


Fig. 5-5. Construction details (bottom view).

hold them securely to the board. A third battery may have to be wired into the circuit to even out variations in performance from one transistor to the next. If your circuit fails to produce a tone in strong light, as described in the next section, another battery may be inserted between the first two. Just keep the connections in series; (Fig. 5-6) the negative terminal of the new battery to the positive of M1, and the positive terminal to the negative of M2. There is no on-off switch; power is turned on by sliding a wire into a Fahnestock clip bolted to the board.

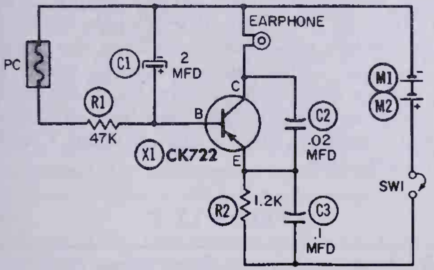


Fig. 5-6. Schematic diagram.

OPERATION

The first trial with the completed unit should be done about six or seven feet away from a 75-watt bulb. Point the photocell to and away from the light source and listen in the earphone. As the cell lines up with the light, the tone should sound. Brighter sources will increase the range of pickup considerably. In the model shown, the tone was heard about 12 feet from a window on a cloudy day.

When you are certain the circuit is functioning properly, put on the blindfold and try to pinpoint the source of light by moving your head in various directions. (The circuit board may be tucked into the blindfold, at the back of your head.) The tone can help zero you in. As you walk toward the light it will grow louder and rise in pitch.

ABOUT THE CIRCUIT

Fig. 5-6 shows how the electronic "eyeball" turns light into tone. The transistor and earphone form essentially an audio-oscillator circuit. However, oscillation cannot commence until the base element of the transistor receives a negative voltage from the battery supply. This function is fulfilled by the photocell which behaves like a variable gate through which electrons from the battery can flow to the base. Unlike some photocells, which produce a small voltage when light falls on them, the photoresistive or cadmium sulphide type used here exhibits a drop in internal resistance, from a high of about 1 megohm to a low of 1500 ohms.

PARTS LIST

Item No.	*Description*
C1	2-mfd electrolytic capacitor, 6-volt.
C2	.02-mfd disc capacitor.
C3	0.1-mfd disc capacitor.
R1	47K, ½-watt resistor.
R2	1.2K, ½-watt resistor.
X1	CK722 transistor.
PC	Photocell, cadmium sulphide type.
M1, M2	1.5-volt penlite cells.
E	Earphone, 2000-ohm magnetic type.
SW1	Switch (see text).
Misc.	Ping-pong ball; perforated board; Fahnestock clip; flea clips; dark cloth; hookup wire.

CHAPTER 6

HOME BROADCASTER

Built inside the cabinet of the small speaker shown in Fig. 6-1 is a miniature broadcast station that can provide hours of entertainment for kids as well as adults. Talk into the speaker and radio waves carry your voice to any nearby a-m radio. It's just the thing for the amateur disc jockey, and a novel surprise for visiting friends. Turn on a radio and leave the room, then start talking into the gadget. By mentioning some familiar names "on the air," you're sure to get a surprise reaction from your listeners.

The range of the broadcaster is about twenty or thirty feet. Although power is extremely low, there's enough to penetrate walls or to travel between floors. It's completely portable and may be used outdoors to transmit to a car radio.

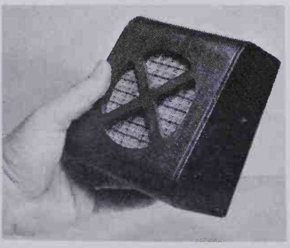


Fig. 6-1. The completed home broadcaster.

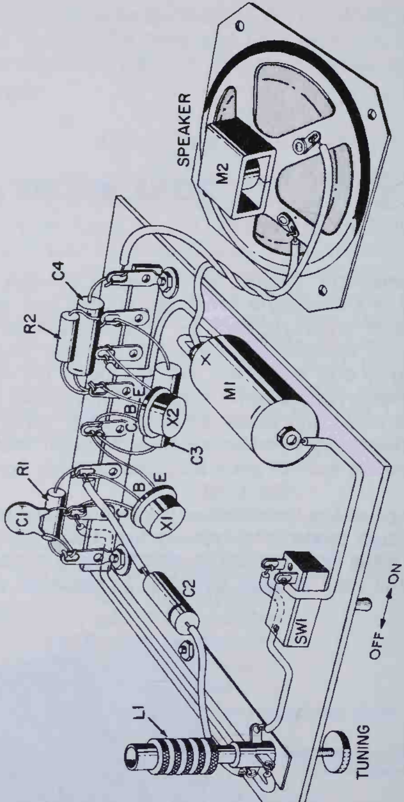


Fig. 6-2. Pictorial wiring diagram.

CONSTRUCTION

In the unit shown, all parts are housed in a small speaker case (including the original speaker, which acts as a microphone). Any homemade enclosure will do as long as it is not made of metal. And any permanent-magnet speaker that can produce sound may be pressed into service as the microphone. The old field-coil type speaker won't work—it needs a power source.

Whatever you choose as the chassis (a piece of hardboard is ideal), lay out the components as suggested in Fig. 6-2. If need be, you may shift them around to fit your space requirement. The following step-by-step instructions describe the model shown here.

Remove the panel of the speaker cabinet; the parts are to be mounted on its inside surface. Begin with coil L1; the mounting bracket usually supplied with it is screwed near one edge of the panel, as pointed out in Fig. 6-3. An 8-lug terminal strip is fastened at the same time. As shown, one mounting foot of the strip and one end of the coil bracket are held by the same nut and bolt.

It's important to check the clearance between the parts and the rear of the speaker beforehand. Fig. 6-4 indicates

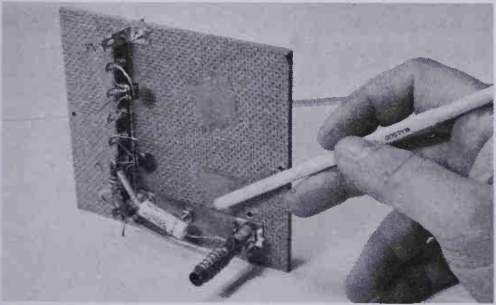


Fig. 6-3. Mounting the coil.

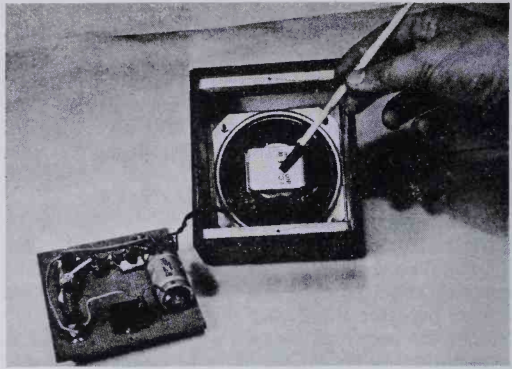


Fig. 6-4. Speaker position.

the position of the speaker frame. This accounts for the various components being laid out along the edges of the panel. When the panel is finally fastened to the cabinet, there will be a clear area for the speaker. Arrange your parts so there is no trouble when the unit is assembled.

Fig. 6-5 reveals more clearly the edge arrangement of components. Notice that the center of the panel is de-

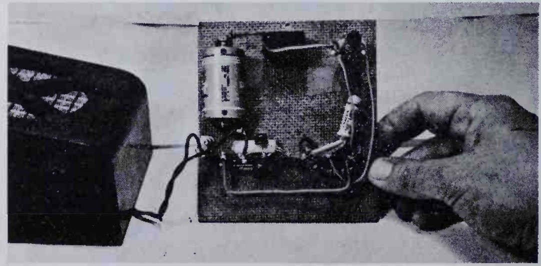


Fig. 6-5. Component arrangement.

void of parts. The twisted wires running to the cabinet connect to the speaker lugs. Don't cut the leads too short; leave enough so the panel can be removed from the cabinet without strain.

Most parts are soldered to each of the eight lugs on the terminal strip. Drill several small holes for nuts and bolts, plus two large enough for the shaft of tuning coil L1 and the on-off switch (Fig. 6-6). The battery is glued into place, or held by a metal strap—a good idea if the unit is likely to be handled roughly.

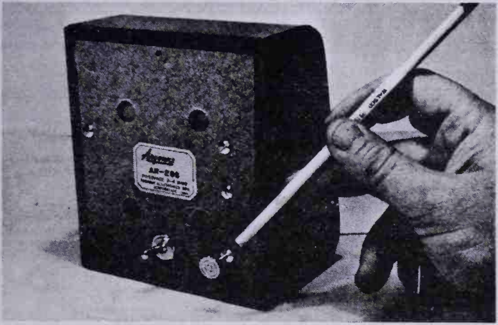


Fig. 6-6. Location of coil knob and control switch.

OPERATION

After checking the wiring, replace the panel. A table radio should be within three or four feet of the broadcaster during this initial trial. Tune it to a dead spot in the vicinity of 500 to 700 kc and leave the volume control at its normal listening position.

Flip on the broadcaster power switch and turn the coil knob on the rear panel. When the broadcaster is on the same frequency as the radio, you'll hear a loud rushing sound in the radio speaker. Start talking directly into the speaker grille of the broadcaster while carefully adjusting the coil knob until your voice is clearest in the radio. The job is somewhat easier if one person talks while another listens and adjusts for voice quality. After the basic tune-up, you'll be able to make additional adjustments with the tuning dial on the radio.

The final step is finding the proper distance to hold the microphone. Distortion can result if you speak too closely into it. Try various distances, while another person checks the quality.

Finally test its range. As mentioned earlier, it should carry your voice many feet between rooms or separate floors in the home. If desired, the range can be extended by adding another antenna to the terminal on the rear of your receiver. This is preferable to lengthening the antenna on the broadcaster, since it reduces the possibility of interference in nearby radios.

ABOUT THE CIRCUIT

Coil L1, in oscillator circuit X1 (Fig. 6-7), generates a radio wave. This wave passes through the wooden cabinet (a metal cabinet would stop it due to the shielding effect of metal) to the outside.

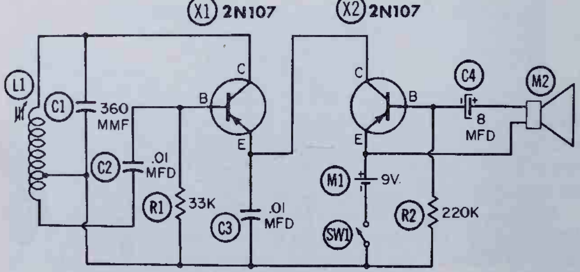


Fig. 6-7. Schematic diagram.

The voice signal originates at the speaker. Audio (i.e., voice) signals from it are greatly amplified by transistor X2 and applied to the emitter terminal of transistor X1. Here they modulate (vary the strength of) the radio signal in step with the voice frequencies.

The table radio picks up and reproduces the modulated signal as if it had been transmitted by a standard broadcast station.

PARTS LIST

Item No.	*Description*
R1	33K, ½-watt resistor.
R2	220K, ½-watt resistor.
C1	360-pf disc capacitor.
C2, C3	.01-mfd paper capacitors.
C4	8-mfd, 15-volt miniature electrolytic capacitor.
L1	Tapped transistor antenna coil (Superex VLT-240 or equivalent).
X1, X2	2N107 transistor.
M1	9-volt transistor battery.
M2	PM speaker, any size (4-inch, 3.2 ohm shown).
Misc.	Cabinet and panel; 8-lug terminal strip; hook-up wire; nuts and bolts.

CHAPTER 7

MUSICAL OATMEAL BOX

This project ventures into the realm of weird musical instruments. Wave your hand at an innocent-looking oatmeal box, and strange sounds are heard from a nearby table radio With a little practice you, the maestro, can actually play tunes and mystify onlookers. Never does your hand leave your body! . . . or touch anything but the air surrounding the jolly character pictured on the box in Fig. 7-1.

As you become a more accomplished musician, you'll be able to play requests from the audience or even gen-

Fig. 7-1. Playing the musical oatmeal box.

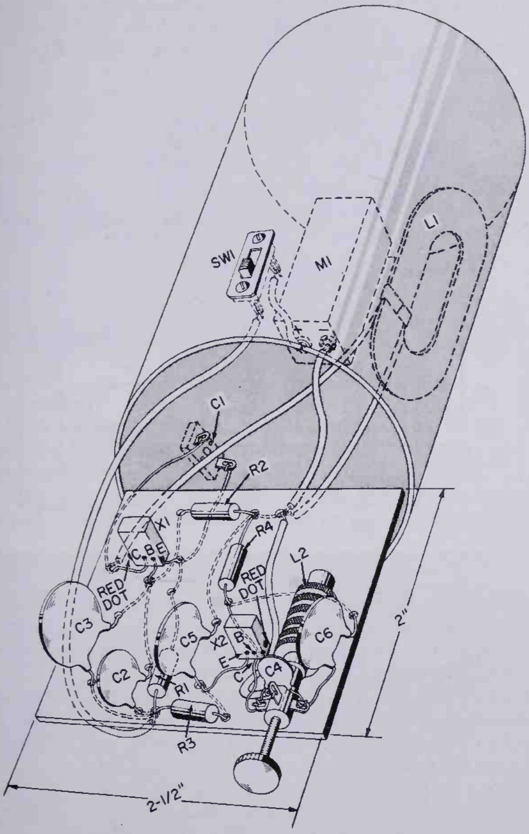


Fig. 7-2. Pictorial wiring diagram.

erate the eerie sounds of a science-fiction movie. Much of the fun is in watching the quizzical look of friends or family as they try to decide whether you're mad, a genius, or a combination of both.

CONSTRUCTION

Take an oatmeal box, hold the on-off switch against the side, and outline its mounting holes in pencil. Cut out the shape (Fig. 7-2) with a razor or other sharp instrument, then puncture two holes for the nuts and bolts that hold

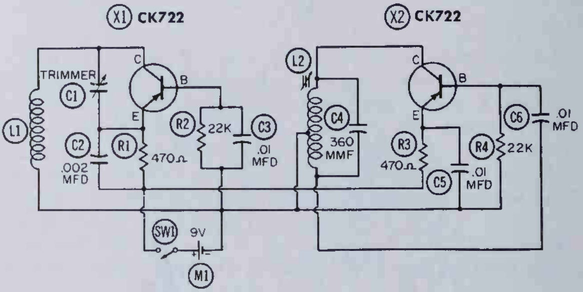


Fig. 7-3. Schematic diagram.

the switch in place. Attach the switch with its two terminals near the top mounting screw of the switch (once the switch is in position). This is done so the power goes on when the switch handle is thrown upward.

Connect two leads to the battery (Figs. 7-2 and 7-3) by soldering to the terminals directly or by using matching battery clips. Then apply glue to the bottom of the battery and press it to the bottom of the box (Fig. 7-4).

Fasten trimmer capacitor C1 to the box by making small slits in the box and pushing the capacitor into them. Dab some glue on loop coil L1 (Fig. 7-5) and hold it to the inside of the box until it remains firmly in place.

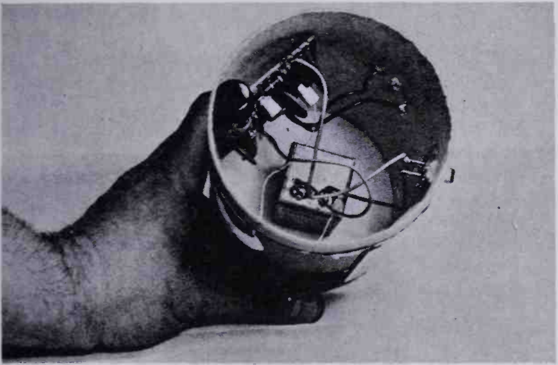


Fig. 7-4. Components mounted inside box.

Now solder 8-inch lengths of hookup wire to the components within the box. The loop has its own leads. If they are short, unravel them so they extend 5 inches.

The box is now put aside while the circuit board is wired. Cut the perforated board to the dimensions given

Fig. 7-5. Gluing the antenna.

in Fig. 7-2, and thread in the leads of the various components. Coil L2 will remain in place after its lugs are soldered to other components. It must stay firmly in position to permit the tuning knob to be rotated. If there is any play, bend a piece of hookup wire into a U and strap the coil to the board. Thread the free ends of the strap through the holes in the board and twist tightly.

Your coil might be supplied with a metal knob which will detune the circuit slightly. Miniature plastic knobs are available for a ⅛-inch shaft.

Other small parts can be threaded to the board and interconnected. As shown in Fig. 7-2, there are no components on the underside of the board, just several solder joints and wire connections. Complete the construction by joining the circuit board to the wires hooked earlier inside the box. Keep the leads long enough so the device can be operated with the board outside the box. This is helpful if you want to check for a wiring error in the circuit. The final step in assembly is gluing the board into the position shown in Fig. 7-4.

OPERATION

Place a table-model radio near the completed project and flip power switch SW1 on. The radio should be set near the low end of the dial, between 600 and 700 kc. Be sure no broadcast station is being received and keep the volume control at a normal listening level.

There are two tuning steps: trimmer capacitor C1 and the knob for coil L2. Notice in Fig. 7-4 that the cover of the box is removed to gain access to the knob. After it has been properly adjusted, the cover may remain in place. Begin by turning the trimmer screw. A nonmetallic screwdriver should be used, but a metal one will serve, although tuning is trickier since the metal shaft will tend to detune the circuit. Find the adjustment that produces a fairly strong hum in the radio speaker. It should drown out any static or background noise. Then adjust the knob of coil

L2. If the hum is lost as this is done, readjust the trimmer to bring it back in. (There is some interaction between the two adjustments.) During this tune-up procedure, be sure neither hand is held near loop coil L1 hidden in the box, or you'll be unable to tune the device properly. To play it safe, grasp the box at the opposite side.

There should be a point where a loud tone is produced in the radio speaker as the knob is turned. On either side of this point, the tone should change in pitch. As the knob is rotated in one direction, the tone will be very high in pitch. As it is rotated in the opposite direction, the tone will drop to zero (known as the zero beat), then rise until no longer audible. The setting you want is near the zero beat, where the tone is very low in pitch. Some trial-and-error tuning is needed to keep the tone at the desired low pitch, since the circuit will tend to lock on zero (between the two audible points).

Now, slowly bring your open hand toward the side of the box. When it touches, it should be directly over the loop coil (mounted inside the box). As this is done, the sound in the speaker will change gradually from a low to a high pitch. You'll need practice, but with experience you'll be able to play simple tunes with a minimum of sour notes. The musical effect is greatly enhanced if your hand quivers as it moves back and forth.

If the number of tones is too limited to permit playing a complete musical selection, retuning is in order. Find the coil adjustment that makes the tone swing over the greatest range of highs and lows as your hand moves back and forth.

ABOUT THE CIRCUIT

As illustrated in Fig. 7-3, the transistors are wired in two circuits that are quite similar in design. Each generates a radio frequency. Trimmer capacitor C1 and coil L2 are used to set each signal on nearly identical frequencies in the broadcast band. The radio picks up energy from both circuits and mixes them. If the two signals are identical, no tone is heard in the speaker (the zero-beat position). But when a slight frequency difference occurs, a tone is audible. A 1000-cycle tone, for example, means the difference between the original radio signals is 1000 cycles.

After the circuits have been adjusted for the lowest possible audio tone, the hand near coil L1 (the loop) alters the circuit inductance, and the output of transistor X1 changes in frequency. Since the frequency of transistor X2 remains constant, a varying audio tone is heard from the speaker.

PARTS LIST

Item No.	*Description*
R1, R3	470-ohm, ½-watt resistors.
R2, R4	22K, ½-watt resistors.
C1	25—280-pf mica trimmer capacitor (Arco-Elmenco No. 464 or equivalent).
C2	.002-mfd disc capacitor.
C3, C5, C6	.01-mfd disc capacitors.
C4	360-pf disc capacitor.
L1	Broadcast loop antenna, miniature type.
L2	Tapped transistor broadcast antenna coil (Superex VLT-240 or equivalent).
X1, X2	CK722 transistors.
SW1	Single-pole, single-throw slide switch.
M1	9-volt transistor battery.
Misc.	Perforated board; oatmeal box; miniature knob; hookup wire; battery clips.

CHAPTER 8

THE FLIP-FLOP

Millions of flip-flop circuits operate daily in today's electronic computers. They are actually electronic switches with no moving parts to wear out. Although the flip-flop finds application in highly complicated circuits, you can build and operate a single flip-flop on a piece of pegboard. In fact, you can perform at least seven separate stunts with the flip-flop shown in Fig. 8-1. Once you become familiar with this particular one, perhaps you'll be able to come up with a half-dozen more. This flip-flop is a versatile building block that lends itself to much modification.

The following projects begin with a simple tone oscillator. The flip-flop is made to generate an audio signal

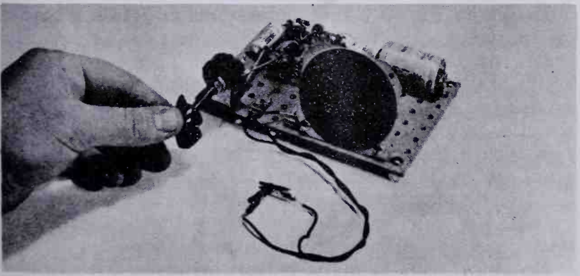


Fig. 8-1. The finished flip-flop circuit board.

which can be keyed for code practice, for example. The circuit switches current to the speaker approximately 400 times per second, which falls into the range of hearing.

Next, a minor change is made to greatly slow the flip-flop and it becomes a metronome. It will tick out a regular beat like the pendulum-type devices students use while practicing on a musical instrument. There's even a control knob for varying the beat.

When the circuit is really slowed down, it becomes a timer. The ticking sound can be adjusted to mark intervals of approximately 15 seconds and less.

Two alarm circuits—both open- and closed-circuit types—are also possible.

The capability of the flip-flop is further exemplified by a final alteration—the addition of a photocell which makes the tone controllable by light.

CONSTRUCTION

A piece of regular pegboard supports the components, and four small L-shaped brackets serve as legs. The bottom of the board should stand about one-half inch above the table top after the legs are fastened. Two similar brackets are attached to the speaker frame so it may be mounted as shown in Figs. 8-2 and 8-3.

Notice in Fig. 8-1 that potentiometer R1 is mounted on a large bracket. Be sure the three lugs on the potentiometer face the center line of the board. Then two terminal strips are bolted on and Fahnestock clips fastened to the front edge at points *A* and *B* in Fig. 8-2. Before screwing the clips in place, mount the two solder lugs on the screws underneath the board. This makes a convenient solder point for the connecting wires.

After these parts are secure, wire the circuit. As shown in Fig. 8-4, few leads are run along the bottom of the board, but several connections are made there.

Matching clips hold the battery in place. First solder leads to the clips, insert them into one of the holes on the board, and push the clips onto the battery terminals. Threading these wires in and out of the holes will help hold the battery in place.

You will need small screws and nuts for the miniature audio transformer, T1. Notice in Fig. 8-2 that the trans-

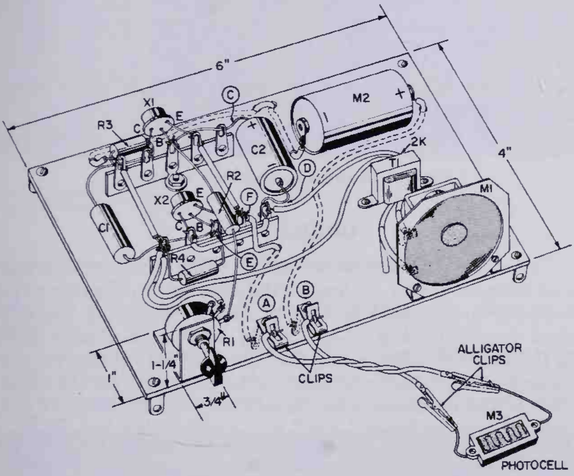


Fig. 8-2. Pictorial wiring diagram.

former primary (2K side) has two wires which connect into the main circuit on the board. The other two leads (voice-coil side) are soldered to the speaker lugs.

After a checkout for proper connections from the transistors and for correct polarity of electrolytic capacitor C2, the flip-flop is ready for service. Note that capacitor C3 appears in Fig. 8-5 but not in Fig. 8-2. It is an optional unit used with the timer and is described in a later section.

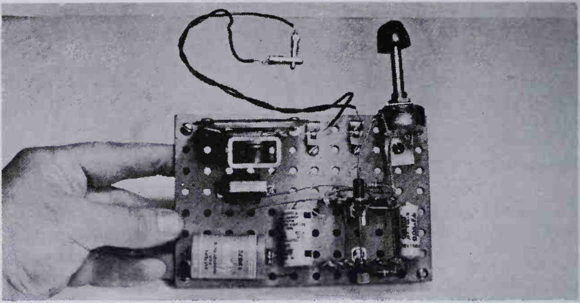


Fig. 8-3. Showing components mounted.

OPERATION

Turn the potentiometer knob fully counterclockwise and connect a pair of leads (the ones with alligator clips soldered to one end) to clips *A* and *B*. Touching the two clips together (Fig. 8-3) should produce a steady tone in the speaker. Notice that the tone may be rapidly turned on and off by making and breaking contact with the clips. This is the code-oscillator function of the flip-flop. If you

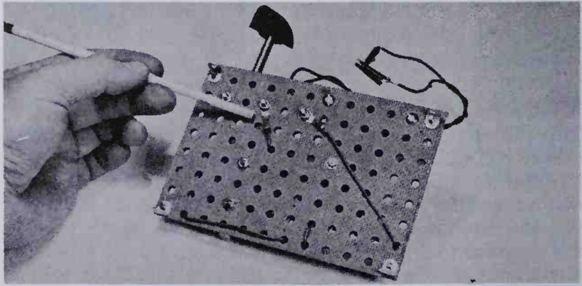


Fig. 8-4. Underside of the board.

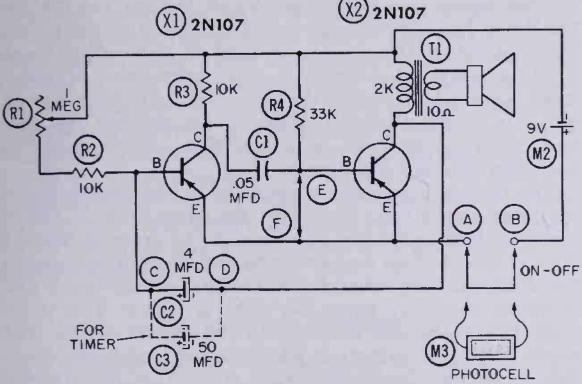


Fig. 8-5. Schematic diagram.

want to use it this way, simply connect the clips to a code key.

There is no power switch in the circuit. Whenever the unit is not in use, snap the alligator clips along the edge of the board so they do not make contact with each other.

Next you might want to try out the circuit as an open-circuit alarm, where the tone will sound in the speaker when a connecting wire is broken. If the circuit were protecting a door or window, for example, a very thin, easily breakable connecting wire would be used. It can be tacked in place across the area to be protected. (The alarm is checked out on a table by placing a single wire across points *E* and *F* in Fig. 8-2.) Apply power by clipping together the alligators from *A* and *B*. When the connecting wire is removed, representing a broken wire, a tone should be heard in the speaker. During this procedure keep the potentiometer knob fully counterclockwise.

If you intend to put this circuit into service for an extended period of time, it's a good idea to provide a heavier power source than the 9-volt battery specified in the Parts List. Though the unit is silent on standby (before the connecting wire is broken), it still draws about 2 milliamperes of current. A more permanent arrangement is five 1.5-volt cells (the kind used for home buzzers) wired in series. Only 7.5 volts will be supplied, but circuit operation will not be appreciably affected and the batteries will last far longer.

The closed-circuit alarm operates in the reverse manner, sounding a tone when the two wires from *A* and *B* make contact. Let's say you want to be warned when a door is closed. Two copper strips can be fastened, one to the door, and the other to its frame, so they touch and complete a circuit when the door is closed. The wires from the board are fastened to the copper strips. The small transistor battery is adequate for long-term operation since the circuit draws no current in the standby condition.

The metronome application of the flip-flop is achieved by rotating the potentiometer knob clockwise. When the knob is fully open, a tick sounds at approximately 1-second intervals. This is probably the slowest rate you'd need for establishing a music beat. Faster rates occur as the knob is turned in the opposite direction, until the circuit breaks into a steady tone. As described in earlier steps, the two clips from *A* and *B* must be joined together to apply power.

Setting up the unit as a timer calls for added capacity in the circuit. You have a choice of almost any electrolytic capacitor, as long as its value exceeds the 4 mfd (C2) already wired in. The new capacitor (C3 in Fig. 8-5) is soldered across points *C* and *D* on the board. In this flip-flop, the timing pulses were 8 seconds apart with 25 mfd added, and 16 seconds for a 50-mfd capacitor. In both instances the potentiometer was fully clockwise. The additional capacitor only determines the longest interval between pulses; you still have the potentiometer for varying their rate.

Another interesting use of the flip-flop is in controlling its tone by light. The photocell (M3 in Fig. 8-5) is of the photoresistive type, which changes resistance when light waves of varying intensities strike it. (Don't use the other type which generates voltage.) Turn the potentiometer fully counterclockwise so the flip-flop is set to produce a steady tone. Then insert the photocell across points *A* and *B* with the aid of alligator clips. By waving your hand or a flashlight over the photocell, you'll find that you can hear the tone when bright light falls on the sensitive surface of the cell. It may not be as loud as in earlier projects, but this is normal.

ABOUT THE CIRCUIT

The flip-flop operates like an electronic "seesaw." In Fig. 8-5, a pulse of current travels through transistor X1, is amplified, and passes on to X2, producing a click in the speaker. But notice that part of the current can return to X1 through capacitor C2. This allows a second pulse to pass over the same path, and the action is repeated. The energy to the speaker is continuous, since the pulses are amplified as they are applied to the transistor bases. A steady tone indicates the pulses are making approximately 400 trips, or cycles, per second.

In the code-oscillator application, a key across points *A* and *B* is depressed to close the power-supply circuit and thereby sound a tone. When the key is raised, power from the battery is cut off and no tone is heard.

The metronome and timer operate by slowing the pulse rate. The metronome depends on the variable resistance provided by the potentiometer and C2, which both delay the pulse signal. The timer requires the addition of capacitor C3 for a longer delay.

The open-circut alarm is a variation of the code-oscillator idea; instead of a key, the connecting wire controls the battery power source. The closed-circuit version uses a different principle. A wire across *E* and *F* prevents the pulse from traveling from X1 to X2. When the wire is broken, normal flip-flop action resumes and the tone again sounds.

The last project, using light control, relies on the ability of the photocell to change resistance with illumination. Notice in Fig. 8-5 that it is in series with the positive battery lead. In subdued light, the cell resistance is too high and the battery current too small to permit flip-flop action. However, strong light rays lower the resistance of the photocell sufficiently for current to flow and thus produce a tone.

PARTS LIST

Item No.	*Description*
R1	1-megohm potentiometer, carbon type.
R2, R3	33K, ½-watt resistors.
C1	.05-mfd paper tubular capacitor.
C2	4-mfd electrolytic capacitor, 15 volts or higher.
C3	50-mfd electrolytic capacitor, 15 volts or higher (see text).
X1, X2	2N107 transistors.
M1	2½-inch speaker; 3.2- or 10-ohm voice coil.
M2	9-volt transistor battery.
M3	Photocell, cadmium-sulphide type.
T1	Audio output transformer, miniature transistor type; 2K to 3.2- or 10-ohm voice coil.
Misc.	Pegboard, 6″ × 4″; L-bracket for pot, 1″ × ¾″ × 1¼″; 2 alligator clips; 2 Fahnestock clips; 2 battery clips; two 5-lug terminal strips; four small L-brackets for legs; knob for ¼-inch shaft.

CHAPTER 9

TODDLER'S TOOTER

Pushing buttons and flipping levers seem to have a strange fascination for the toddler set. With the gadget shown in Fig. 9-1, they can play to their heart's content.

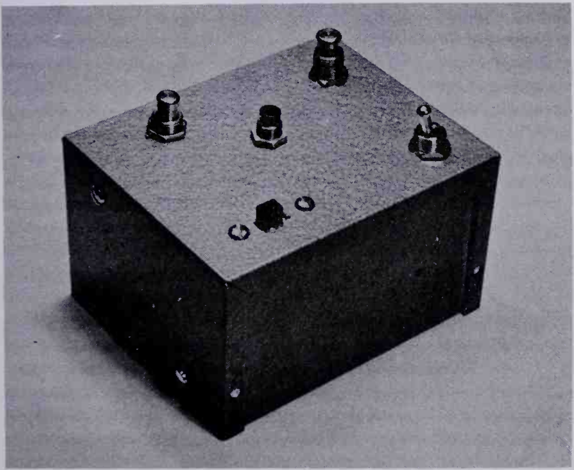


Fig. 9-1. The completed toy.

As they push the buttons mounted on its top panel, an unending series of tones is emitted from a speaker inside the box. Not only are there five separate "toots," but dozens of different tones can be produced from the different switch combinations.

CONSTRUCTION

A standard aluminum "minibox" houses all components. As shown in Fig. 9-2, bolt the two terminal strips,

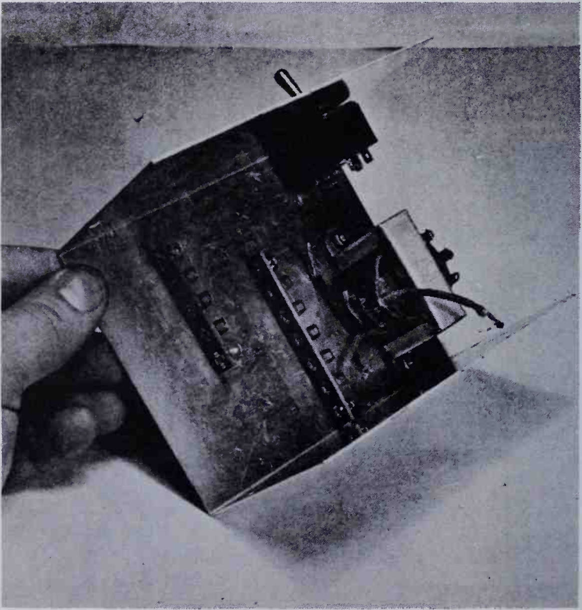


Fig. 9-2. Mounting the terminal strips, switch, and transformer.

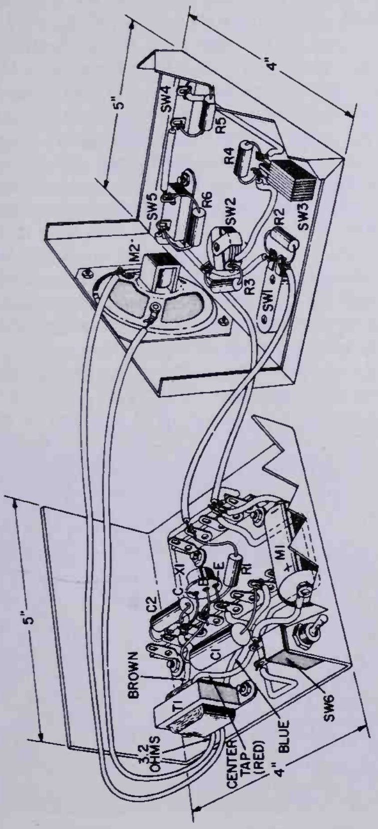


Fig. 9-3. Pictorial wiring diagram.

the on-off switch, and the transformer on the inside of the box. Next wire in the transistor (Fig. 9-3) and other small parts, and attach the four long, flexible leads that connect both halves of the box together. Make these wires about 10 inches long so the box may be easily separated later without unsoldering connections.

T1 can be almost any push-pull audio-output transformer; it need not be the kind used for transistor circuits. Its primary winding has three leads, usually color-coded red, blue, and brown; and these are connected as shown in Fig. 9-3. The rating for this side of the transformer may be any value from 4000 to about 8000 ohms; while the secondary winding, which is connected to the speaker, must be 3.2 ohms. However, if you use a 10-ohm speaker, as in the original model, the mismatch will not significantly affect circuit performance.

The major components in the other half of the box are the switches and speaker (Fig. 9-4). Before mounting the speaker to the side panel, drill a series of small holes

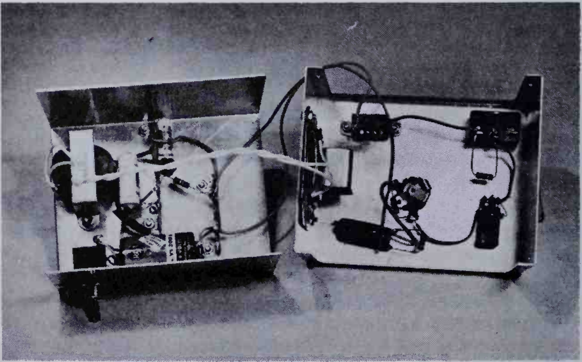


Fig. 9-4. All components wired in place.

as shown in Fig. 9-5 so the sound may reach the outside. Keep the holes small so the kids can't poke anything into the box and puncture the speaker.

Although five switches were used in the original unit (Fig. 9-6), you may add more if you wish. Simply connect additional resistors in the same manner as the first five. Any resistor between 1000 ohms and 1 megohm will change the tone as its associated button is pressed. The type of switch is not critical either, except they should all be the same for uniform appearance.

OPERATION

Turn on power switch SW6 and try all the switches. You should hear a number of tones. Notice that their complete register, or range, will change if any switch is held down as others are pressed.

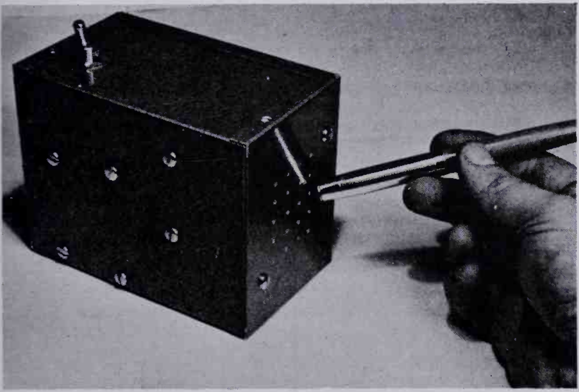


Fig. 9-5. Holes for sound to come through.

ABOUT THE CIRCUIT

As shown in Fig. 9-6 the unit is an audio oscillator which operates by virtue of feedback between the transistor collector and base. The output signal is fed to the base through capacitor C1, and a steady tone is heard from the speaker. The frequency of the signal is controlled by switching resistors in and out of the base circuit. As SW1 through SW5 are closed in different combinations, the time constant of the circuit—and thus its frequency—is varied. Resistor R1 is in series with the base to protect the transistor from overload. Even if all the switches were to short, R1 would limit the current

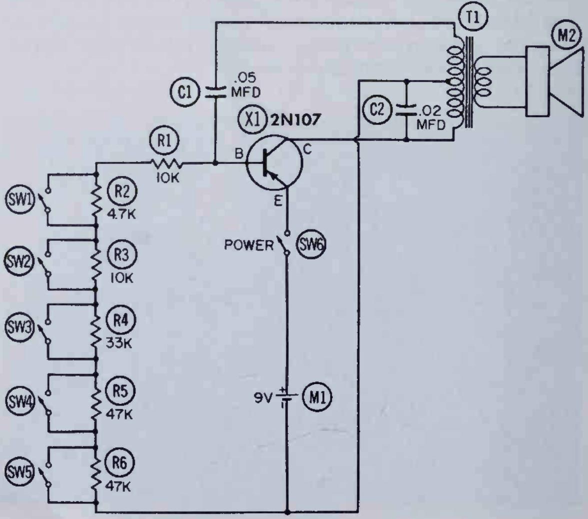


Fig. 9-6. Schematic diagram.

that flows from the negative battery terminal to the base element.

PARTS LIST

Item No.	*Description*
R1	10K, ½-watt resistor.
R2	4.7K, ½-watt resistor.
R3	10K, ½-watt resistor.
R4	33K, ½-watt resistor.
R5, R6	47K, ½-watt resistor.
C1	.05-mfd paper capacitor.
C2	.02-mfd paper capacitor.
X1	2N107 transistor.
T1	Push-pull audio-output transformer (see text).
M1	9-volt transistor battery.
M2	Speaker, 2½-inch.
SW1 through SW5	Any type of SPST switch (push-button, slide, toggle, etc.)
SW6	SPST toggle switch.
Misc.	Aluminum box 5″ × 4″ × 3″; one 7-lug terminal strip; one 5-lug terminal strip; hook-up wire.

THE RADIO CLOCK

Unlike the usual approach where a clock is built into a radio, the radio in this project is assembled within a clock. The result greatly extends the function of the kitchen timepiece. From its position on the wall the clock not only gives the time of day, but entertains as well.

The radio section consists of a 3-transistor circuit, which delivers adequate volume on strong local stations. No attempt was made to miniaturize the project so the clock must be about 3½ inches or more in diameter. However, if you wish to use a smaller clock, the size of the electronics can be reduced by using a smaller speaker and battery. No matter what you decide to use, the instructions given here are only suggestions, since the dimensions are almost certain to vary from clock to clock. The completed "clock" radio is tunable and has an on-off switch. Fig. 10-1 shows the tuning knob, located behind the face of the clock, being turned by hand.

CONSTRUCTION

The first step is to cut a piece of perforated board (Fig. 10-2) to the general outline of the clock's rear surface. (This turned out to be 3″ × 3½″ in the original model.) Next, mount the speaker with two screws and nuts. The coil-mounting bracket, which should be supplied with the coil, is held to the board by one of the screws that holds

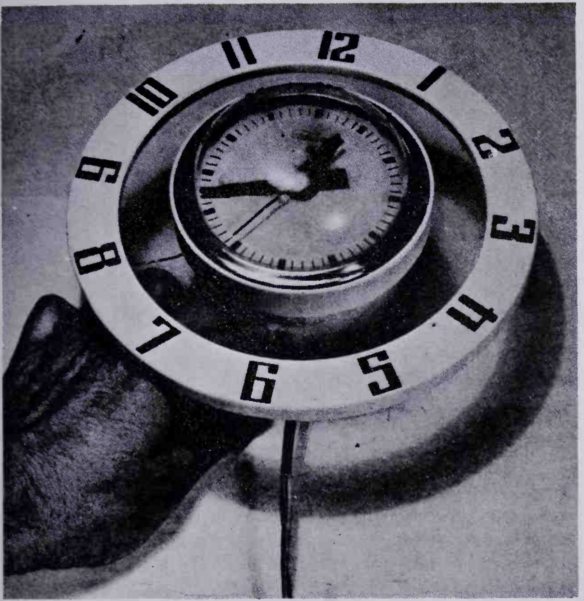


Fig. 10-1. The completed radio clock.

the speaker. The other speaker mounting screw holds one tab of transformer T1. Only a single screw is necessary because of the lightness of T1. Also fastened to the speaker is the on-off switch; it is soldered to the speaker frame in the position shown in Fig. 10-3.

At this point, see if the board fits snugly against the rear surface of the clock. If the clock knob (which allows the time to be set) interferes, cut a hole in the board so the knob can protrude through it. Avoid covering the keyhole opening which permits the clock to be mounted on

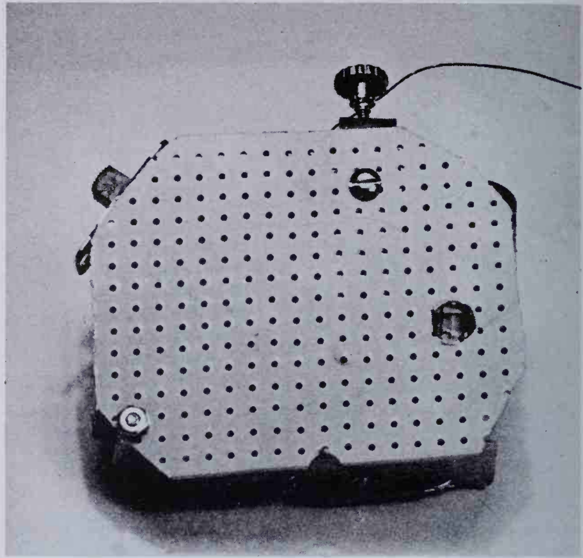


Fig. 10-2. Circuit board shape.

the wall. If necessary, notch the board so the screw or nail which holds the clock to the wall may be inserted into the clock keyhole.

The single terminal strip used in this project is one of the miniature 6-lug types. Its mounting foot, located in the center of the strip, is soldered directly to one speaker terminal. A transformer wire will also be connected to this lug, but will not affect the performance.

A subchassis (Fig. 10-4) measuring about 2½″ × 1″ is cut from a piece of perforated board. This subchassis,

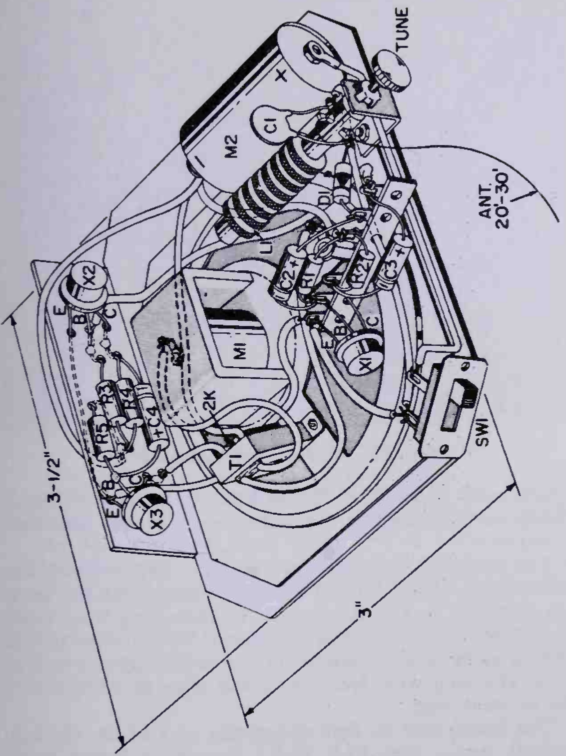


Fig. 10-3. Pictorial wiring diagram.

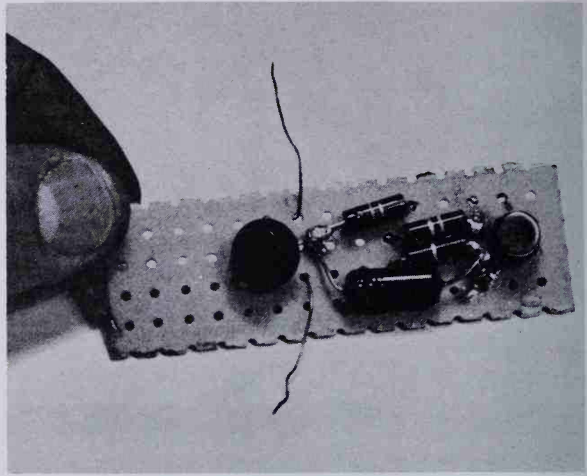


Fig. 10-4. The transistor subchassis.

which holds transistors X2 and X3, may be wired separately and mounted to the main board during final construction.

The project is completed by installing and soldering the small parts as shown in Fig. 10-3. Notice that the parts are fastened to the subchassis by threading their leads in and out of the holes on the board. The finished model, just prior to being mounted on the clock, appears in Fig. 10-5. The long wire from the lower edge of the board is the antenna lead.

The board may be mounted to the rear of the clock in several ways. (See Fig. 10-6.) One is to fasten small metal tabs to the board by screwing them into the rear panel of the clock. Just be certain that any screws

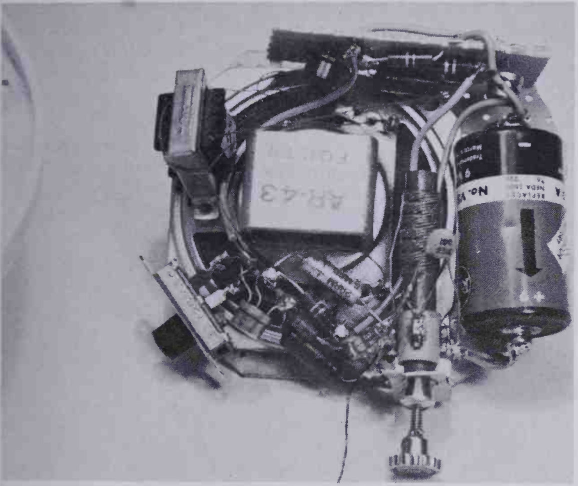


Fig. 10-5. The completed circuit with antenna.

mounted to the clock itself do not touch the two a-c wires from the wall outlet. Another workable system is simply to glue the board in place, using two or three dabs of household cement. This permits the board to be removed for changing the battery (which, incidentally, should give many months of service).

The length of antenna wire depends on the strength of local radio stations. In most areas, twenty feet of wire will suffice.

OPERATION

As shown in Fig. 10-7, the radio is powered by on-off switch SW1, and the tuning knob of L1 allows the sta-

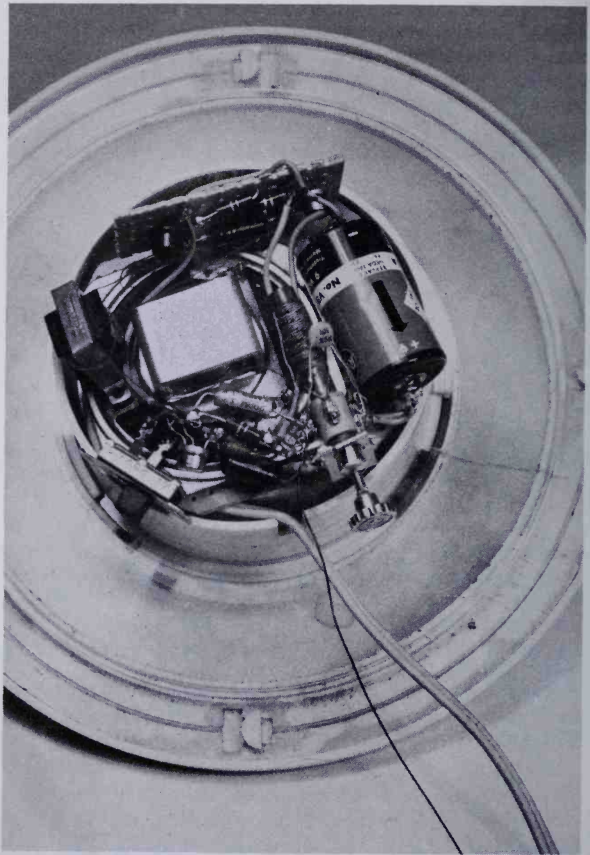


Fig. 10-6. The radio mounted on the clock.

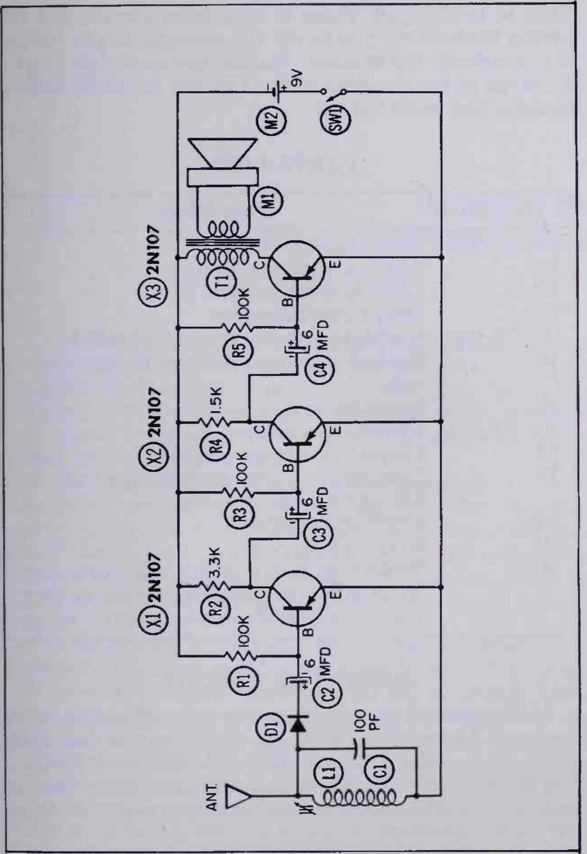


Fig. 10-7. Schematic diagram.

tions to be changed. There is no volume control, but the tuning knob allows you to cut the strength of the station if it overloads the speaker. Besides increasing its length, a change in the direction of the antenna might be helpful in achieving more volume.

PARTS LIST

Item No.	*Description*
R1, R3, R5	100K, ½-watt resistor.
R2	3.3K, ½-watt resistor.
R4	1.5K, ½-watt resistor.
C1	100-pf disc capacitor.
C2, C3, C4	6-mfd, 15-volt electrolytic capacitor.
M1	2½-inch speaker; 3.2- or 10-ohm voice coil.
M2	9-volt battery.
X1, X2, X3	2N107 transistor.
L1	Loopstick antenna coil.
T1	Transistor output transformer; 2K to 3.2- or 10-ohm voice coil.
SW1	SPST slide switch.
D1	Diode, 1N34.
Misc.	Perforated board; 6-lug miniature terminal strip; hookup wire; antenna wire (No. 28 enamel-covered copper).

ABOUT THE CIRCUIT

Tuning circuit L1-C1 selects the desired station when the knob is rotated. The audio component of the radio wave is separated at diode D1 and passed to X1, a transistor amplifier. The audio currents are further amplified in the next two transistors, and the resulting energy drives the speaker.

CHAPTER 11

"BORIS," THE TALKING SKULL

Skip this project if you are prone to nightmares, scare easily, or are inclined to duck at the sight of a bat. As you can see in Fig. 11-1, Boris is a weird sight. He'll sit on a shelf or in the palm of your hand and shock, entertain, or puzzle everyone within earshot. He speaks—a faculty rare among bodyless boneheads.

The voice of Boris is provided by some tricky transistorization packed inside his cranium. The effect is greatly enhanced by the fact that you can walk around the room with Boris as he clacks his mandibles and gabs away. There are no trailing wires to kill the illusion. It's a fun project that convinces any group that a spook actually spoke.

Boris derives his verbal powers from a wireless audio system. The source of his voice can be one of a variety of devices. Basically, anything that has a speaker output can serve as a voice sender. This includes a tape recorder, phonograph, amplifier, or radio receiver. The speaker is disconnected, and the audio signal fed into a loop of wire strung around the room. The audio signal, instead of being heard in the usual manner through a speaker, is converted into a varying magnetic field.

Boris contains an induction-type receiver. Installed where his brain used to be is a pickup, the kind used for recording telephone conversations. It intercepts the magnetic field from the loop and drives a transistor amplifier and speaker. The original signal emanates from the skull. The various ways Boris can use his electronic voice are described later in the section on "Operation." He can recite poetry, carry on a conversation with you, or simply sit and sulk.

Where does one obtain a skull? Though Boris is lifelike in every respect, you don't have to look far to dig one up. Any well-stocked stationery or department store sells

Fig. 11-1. Meet Boris, the talking skull.

them in kit form as scientific projects. Molded from plastic, they are anatomically correct down to the *foramen magnum*—the big hole in the head where it meets the neck. Assembly of the skull takes just a few minutes and is mostly a job of gluing the teeth in place.

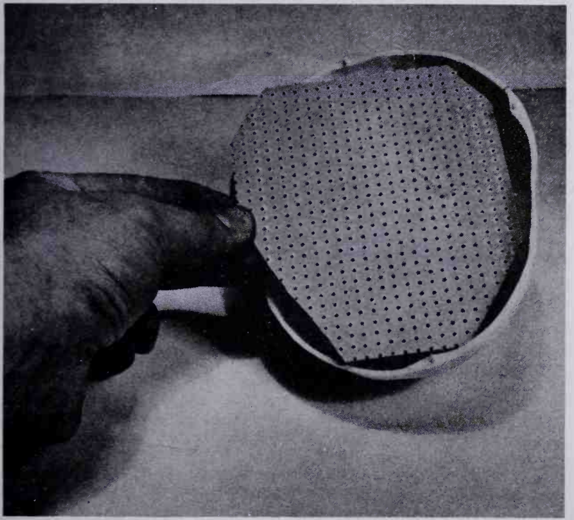


Fig. 11-2. Shaping the circuit board.

CONSTRUCTION

A piece of perforated electronic pegboard (Fig. 11-2) supports most of the circuitry. The exact dimensions of the board can't be given since it will have an irregular shape that must be fitted into place.

The board is held in the top, or removable part, of the skull and the edges trimmed accordingly. Fig. 11-3 gives the approximate dimensions; the final fitting is up to you.

Notice the oblong hole cut into the board to accommodate the pickup (the long black object). The opening is made by drawing the shape in pencil, drilling some large holes inside it, and cutting them out with a hacksaw. Another hole is cut out for the ON-OFF switch.

Next, flea clips for supporting the small parts are pushed into the board holes. Notice in Fig. 11-3 that two pieces of bare wire are strung nearly the full width of the board. These are bus bars used for bringing the positive and negative leads of the battery onto the board. The leads of several small components are soldered directly to them. (Bare wire may be secured by stripping the insulation from a piece of hookup wire.)

The battery is held to the underside of the board by its matching terminal clips. The negative battery clip is pushed onto the battery terminal. Then it is soldered to the underside of the same flea clip that holds one of the bare bus wires on top of the board. (This is the clip near resistor R5 and transformer T1.) The positive battery clip is connected to the flea clip that has a wire running to one of the switch terminals.

While performing the following steps, be sure the switch is turned off in order to prevent accidental shorting of the battery.

The pickup has a cable consisting of a center lead shielded by an outer conductor shield. After the wire and shield are wired to the board, unravel some of the shield and solder it to the clip that supports the bus wire running alongside the large oblong cutout.

The remainder of the board assembly consists of soldering resistors and capacitors to the proper points, as shown in the pictorial drawing. The 1000-ohm transformer leads must face inward toward the board, and the 3.2- or 10-ohm voice-coil wires are run close to the edge of the board.

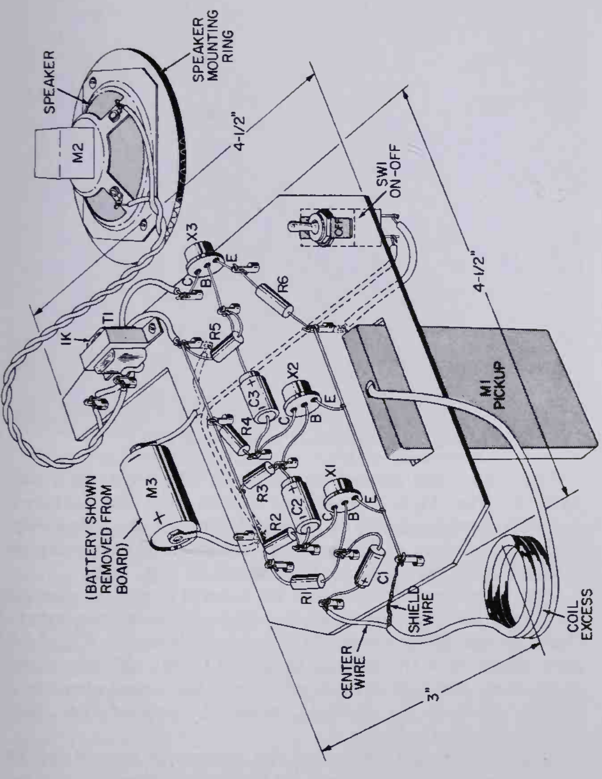


Fig. 11-3. Pictorial wiring diagram.

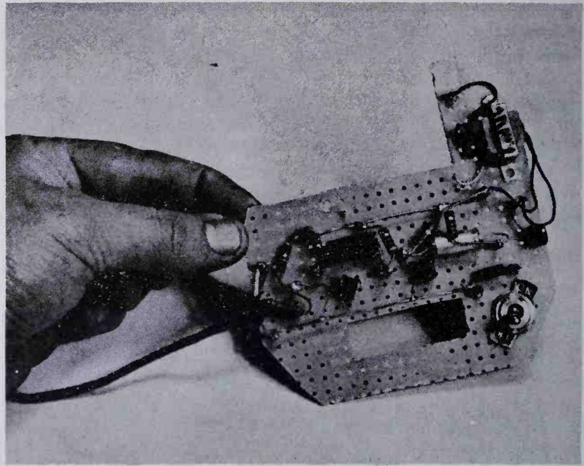


Fig. 11-4. Completed circuit (top view).

The completed circuit should look like Figs. 11-4 and 11-5. In Fig. 11-5, the pointer shows how the battery's negative terminal clip is soldered directly to a flea clip. Upon completion of the wiring, the circuit board may be lowered into the skull, as illustrated in Fig. 11-6.

The board is held in place by several drops of glue on its edges, but it's best to wait until you are certain everything is operating correctly before applying it. Fig. 11-6 also shows how the pickup is placed in the oblong cutout in the board so that it protrudes from the board about two inches. This is no obstacle, since the top of the skull affords ample room for it.

The vertical placement of the pickup is important. If located in another position, its ability to respond to magnetic waves will be seriously impaired.

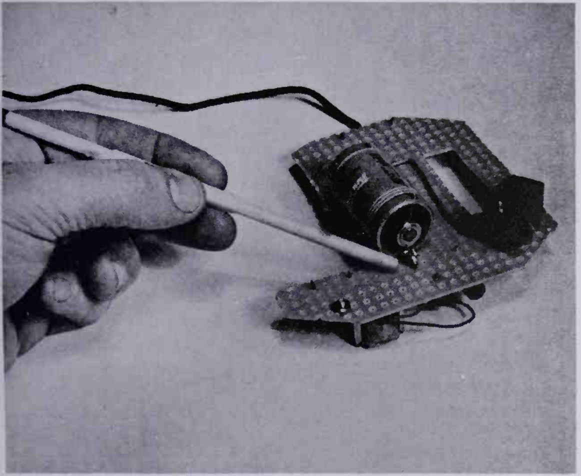


Fig. 11-5. Completed circuit (bottom view).

The pickup is supplied with a long cable. Rather than cut it to length and thereby limit its future usefulness, a better idea is to coil the excess of the cable and tuck it under the board.

Referring to Fig. 11-7, prepare the top of the skull by drilling a series of small holes into it, as shown. This allows sound to reach the outside.

The speaker mounting is prepared next. The mounting ring shown in Fig. 11-8, provides a snug fit for the speaker inside the skull. If not mounted this way, sound from the back of the speaker would combine with waves emitted at the front. Some cancellation of energy would occur and thus reduce the volume.

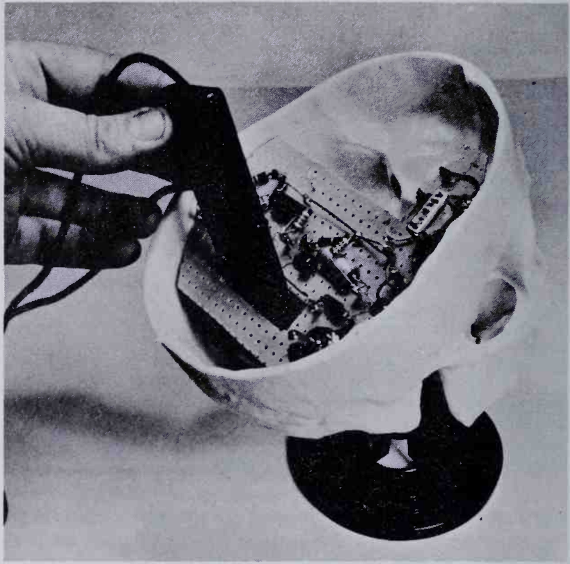


Fig. 11-6. Placement of board in skull.

Cut the mounting ring from a piece of corrugated cardboard (the thick kind used for grocery cartons is ideal). The over-all size is about 3½″ × 4″, but again you'll have to do some fitting. Snip its edges so the piece approximates a snug fit inside the skull. Cut a round speaker hole 2½″ inches in diameter in the ring, and fasten the speaker with screws and nuts.

The next step in the mounting procedure is given in Fig. 11-9. Apply glue to the outer edge of the ring, and press the whole assembly into place with your thumb.

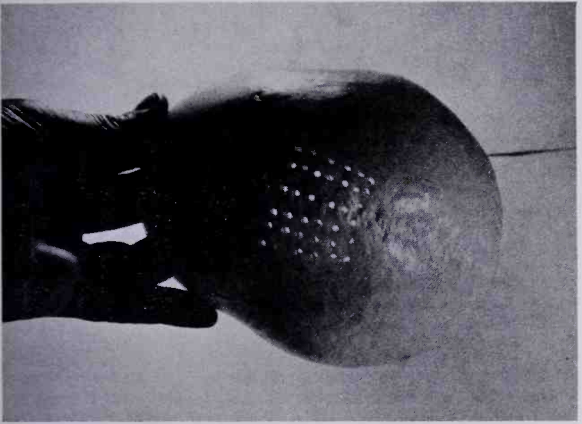


Fig. 11-7. Holes drilled in top of skull.

Use enough pressure so the cardboard conforms to the irregular shape of the skull. Hold the cardboard until it is firmly glued.

The final pair of wires is now installed. Position the two halves of the skull as shown in Fig. 11-10, and prepare the speaker wires. About eight inches of hookup wire will serve for each connection. This length of hookup wire permits the skull to be opened without straining the rest of the circuitry.

OPERATION

A fast check for proper operation of the circuit can be done with a soldering gun. Place the body of the gun within two inches of the pickup coil and press the trigger. A loud hum should sound in the speaker. Another test is

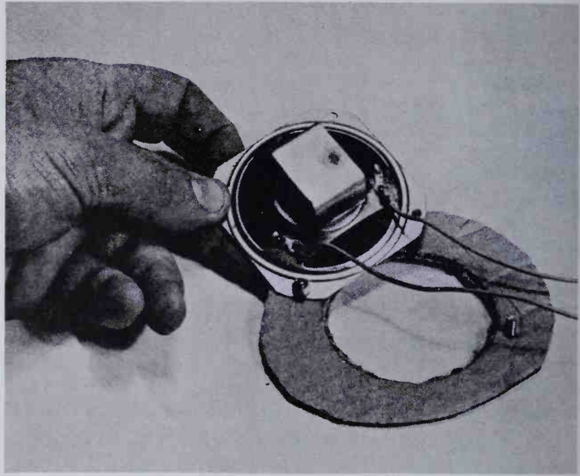


Fig. 11-8. Preparing the speaker mounting.

to tap a coin or key against the flea clip, where the center wire of the pickup cable is soldered. With each tap you should hear a corresponding "click" in the speaker. The power must be on during both tests.

Setting up the entire system requires some preparation of the sender. As described earlier, this can be any equipment with a speaker output. The results are most impressive with a tape recorder, but the following suggestions apply to any system.

Fig. 11-11 shows the essential hookup. Unless the equipment has a jack designed for external speaker output, you'll have to remove one speaker wire. Connect one end of a long length of No. 28 enamel wire to the free end of the speaker wire, loop it around the room, and solder it

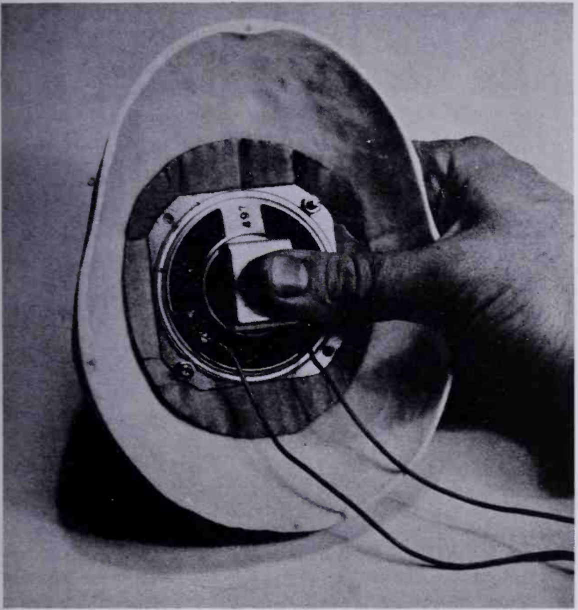


Fig. 11-9. Mounting the speaker.

to the other speaker wire. These connections divert the output of the audio amplifier to the wire loop.

The length of the loop is not critical. In fact make it long enough so it can run to another room and be laid out along its walls or baseboard.

Now operate the tape recorder or other device being used as the sender. If Boris is carried within the confines of the loop, sound should be heard from the speaker.

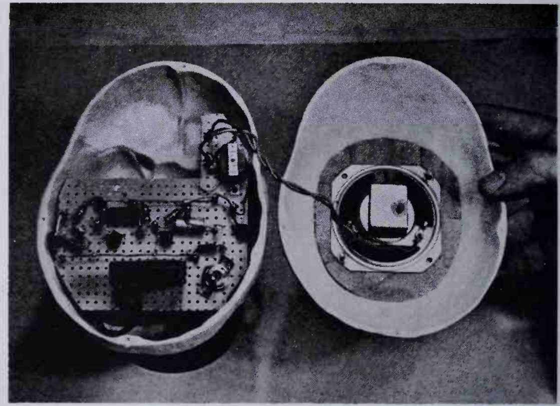


Fig. 11-10. The completed project.

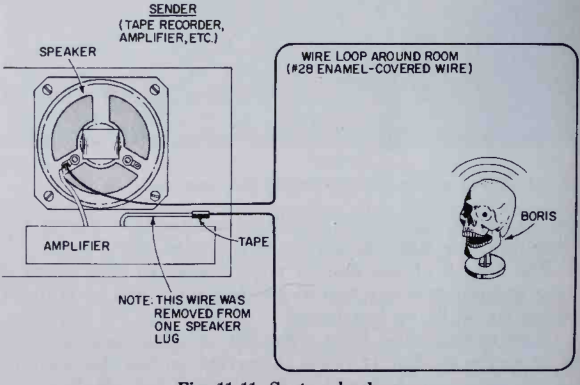


Fig. 11-11. System hookup.

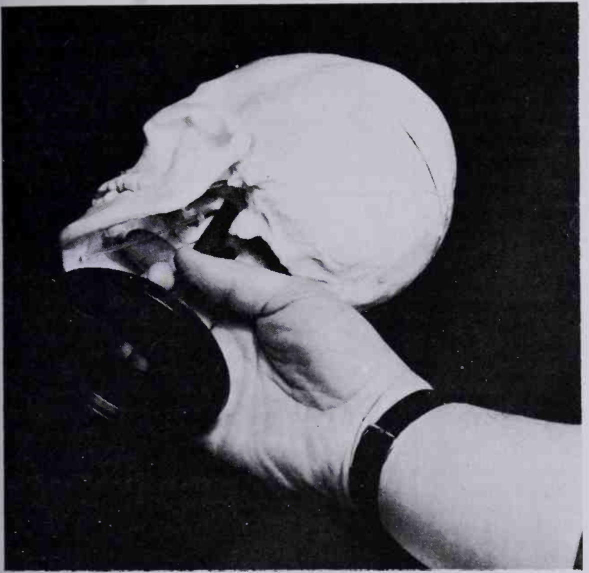


Fig. 11-12. Working the jaw with a rubber band.

It's a good idea to check each section of the room for proper pickup. If you hit a dead spot, simply avoid it when Boris is put into service. Try to stay within areas that produce ample volume. Varying the volume control on the tape recorder, too, can affect the loudness of sound.

Boris is most fun when operated from a tape recorder concealed in another room. His comments may be prerecorded with suitable remarks. A very effective performance is to ask him questions—which he promptly answers. Of course, this is done by leaving pauses on the tape while

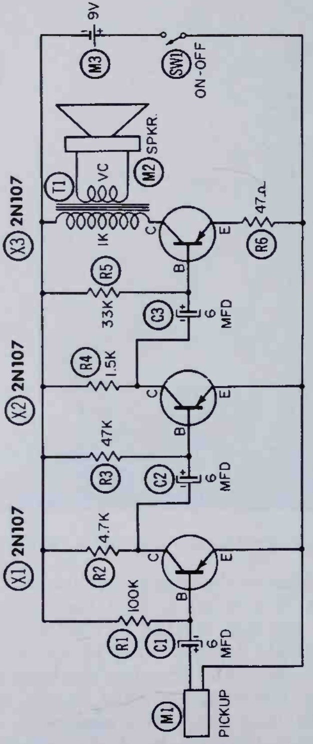


Fig. 11-13. Schematic diagram.

you are talking. It takes some rehearsing but is worth the effort.

Another opportunity for exploiting Boris' talents is to use an amplifier. (Many hi-fi amplifiers have a microphone input.) In this instance an accomplice speaks into the mike while you carry on the dialogue with Boris.

If neither of these alternatives is available, a satisfactory show can be put on with a phonograph. It does require the cutting of a record, but there are inexpensive acetate discs for home use.

The effect of your talking skull is considerably heightened if the lower jaw is made to move as the words issue forth. You could use a small, battery-operated motor, but Fig. 11-12 shows a simpler approach. The skull is already

PARTS LIST

Item No.	*Description*
R1	100K, ½-watt resistor.
R2	4.7K, ½-watt resistor.
R3	47K, ½-watt resistor.
R4	1.5K, ½-watt resistor.
R5	33K, ½-watt resistor.
R6	47-ohm, ½-watt resistor.
C1, C2, C3	6-mfd, 15-volt electrolytic capacitors.
X1, X2, X3	2N107 transistors.
T1	Transistor output transformer, 1K to 3.2 or 10 ohms.
M1	Telephone pickup coil.
M2	Speaker, 2½-inch.
M3	9-volt transistor battery.
SW1	SPST toggle switch.
Misc.	Perforated board; No. 28 enamel-covered wire; skull (see text); flea clips; corrugated cardboard; hookup wire; hardware.

equipped with a movable jaw which is held closed by a rubber band. If you discreetly slip a finger around the band, you can work the jaw much like a ventriloquist's dummy. The base of the skull rests in the palm of your hand, and you can roam about the room while Boris chatters away.

ABOUT THE CIRCUIT

For those interested, Fig. 11-13 shows a detailed schematic of the amplifier in Boris' head. The audio signals emitted from the wire laid around the room are received by M1 pickup and transformed into electrical signals. These signals are then amplified in the three-stage resistance coupled amplifier and heard in the speaker as audio.