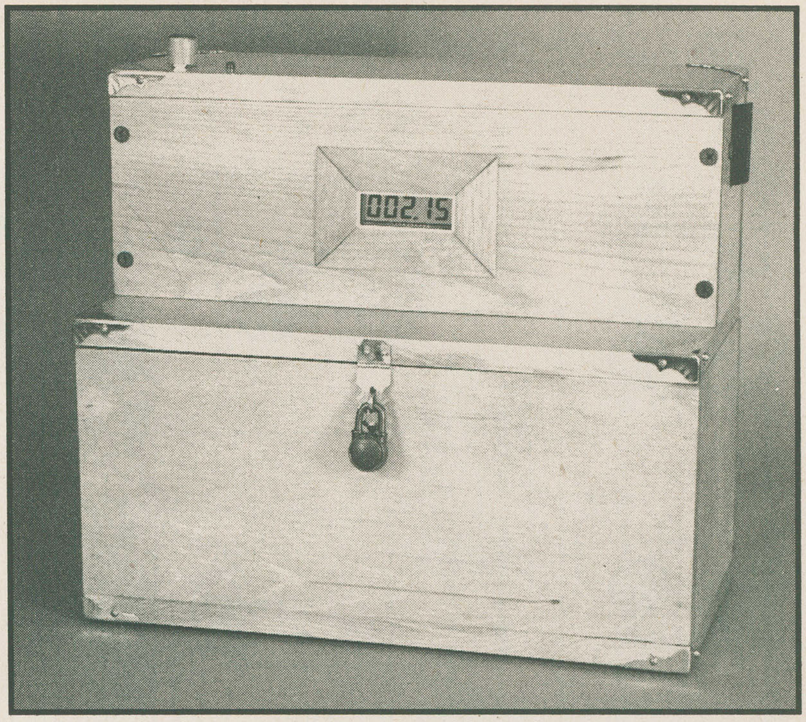
An old-fashioned look combined with digital operation will make you want to trash your old pink piggy—this bank keeps track of what you save!



Build the "SLOT-MACHINE" Electronic Bank

BY MARC SPIWAK AND JOHN YACONO

Did you ever stop to think that by merely saving your daily pocket change, you can gradually accumulate a small nest egg that can be used to fuel some of your hobby interests? It's true, a buck or so a day adds up to well over $300 a year. The only problem is that finding out how much change is in a bottle or jar can be a pain in the neck. You could certainly go out and buy a bank that counts change, but for a true hobbyist, that's cheating (and for most of us, it's expensive). We now present a project—an old-fashioned *"Slot-Machine" Bank*—that's inexpensive, fun to build, and will also encourage you to squirrel away some money for your next project. It even makes a nice gift for children and adults alike.

You just feed nickels, dimes, or quarters into a slot on the side of the bank, the bank figures out what coin denomination has been inserted, and the total is updated and displayed on the front panel. Pennies will register as a dime, so they shouldn't be inserted; besides, they don't add up to much and would waste a lot of space anyway. The circuit can count up to a thousand dollars, so you can build your bank just about as large as you please.

A little bit of high tech is what gives the bank its ability to actually "see" what coin has been inserted. Three infrared (IR) emitter/detector pairs are positioned in the coin chute so that a dime will block one of them, a nickel two, and a quarter all three. A circuit, made up of a handful of components, then decodes the information and sends it to the counter/display module. That is, of course, a simplified explanation of how the bank works, but we'll get to the details later on.

To operate the bank, all you have to do is push a button on the top of the bank to activate it; a green LED lets you know it's on. Then, after inserting a coin in the slot, a beeper counts off the number of cents in the coin as the display counts up in single increments. The only hitch is that you do have to wait for the bank to finish counting one coin before inserting another.

The bank could have been made so that it's on all the time, but the current draw from the IR LED's would quickly drain the batteries. That's why the pushbutton is used to manually activate the unit; a timer circuit gives you approximately ten seconds to insert a coin before power shuts off. However, every coin inserted re-starts the ten-second delay so you don't have to keep pushing the button.

The Timer. Before we discuss the bank's circuitry, we should explain a little bit about the functioning of the special LS7210 programmable timer it contains. Unfortunately, the LS7210 is so versatile that we won't be able to discuss all its features, so we'll have to gloss over some of its abilities for the sake of brevity.

The timer is capable of operating in four different modes. You select a mode by placing the appropriate binary value on its two mode-select pins. We will use the one-shot (monostable) mode, which is chosen by tying the mode-select pins (pins 1 and 2) low.

The chip can work with an external or

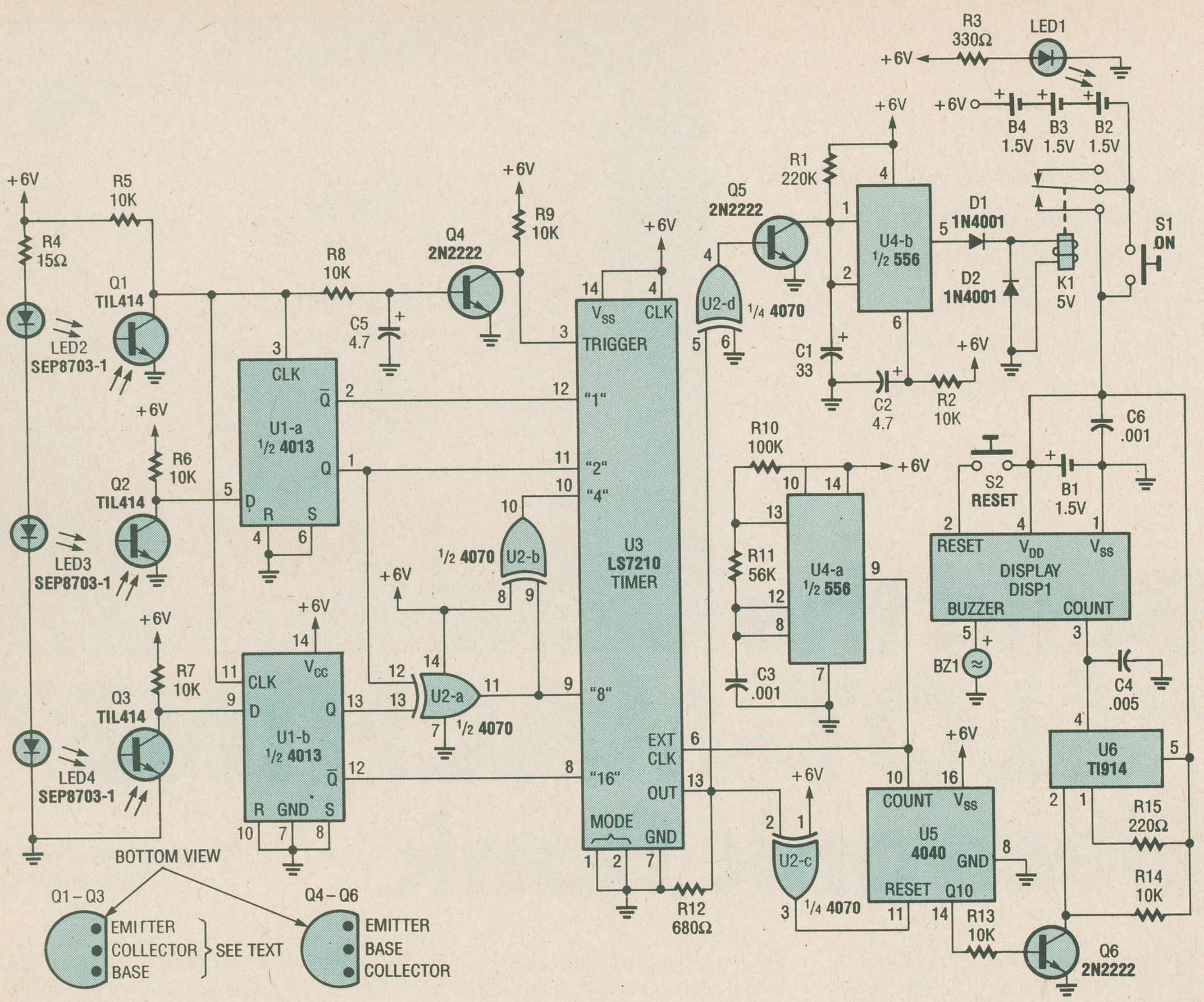


Fig. 1. This is the circuit for the "Slot-Machine" Bank. The phototransistors on the left determine what coin has been put in the slot and that is converted into pulses for the counter.

internal clock. As you'll see, we will need a clock that can oscillate between ground and +V to provide the proper logic-level signals needed to operate other parts of the circuit. The internally driven clock does not swing up and down that far, so we must use an external clock. The external-clock mode is selected by tying pin 4 high. The external oscillator can run continuously without affecting the timer's output; the timer will only become active when its trigger input (pin 3) is toggled.

The trigger input can be positive- or negative-going depending on the timer mode used. For monostable mode, only negative transitions trigger the timer; positive ones are ignored. When a negative transition is presented to the trigger input, the output (pin 13) goes high for one timing period.

The length of the timing period is determined by the frequency of the external oscillator and the logic levels at a series of pins (pins 8–12) called the "weighting-factor inputs." Those inputs accept the binary 1's complement of a number aptly called the "weighting factor." That number programs the timer to hold the output high until the clock has gone through a certain number of transitions. The number of clock pulses (P) counted by the timer is given by:

$$P = 1 + 1023W$$

where W is the weighting factor. In that sense, the timer is similar to a programmable counter, which is how it's used in the bank circuit.

If W is six when the monostable is triggered, the timer will count 6139 pulses before going low again. If we send the pulses to a binary divider with a 2^{10} (1024) output, that output will go high 5 times. If W is 11, that same divider output pulses 10 times, and if W is 26, the divider yields 25 pulses. Each of those divisions has a remainder, so the divider must be reset to zero after each coin value is tallied to be useful for counting coins—but that's taken care of, as you'll soon see.

The Circuit. The "Slot-Machine" Bank uses some common components in an interesting fashion to provide some unusual features. One key component, that is not so common, is the counter/display module denoted DISP1 in the schematic diagram shown in Fig. 1; fortunately, it can be purchased from Radio Shack (see Parts List). It comes as a

PARTS LIST FOR THE "SLOT-MACHINE" BANK

SEMICONDUCTORS

U1—4013 dual flip-flop, integrated circuit
U2—4070 quad XOR-gate, integrated circuit
U3—LS7210 programmable-timer, integrated circuit
U4—556 dual oscillator/timer, integrated circuit
U5—4040 12-stage binary-ripple counter/divider, integrated circuit
U6—TI914, or similar, transistor-output optoisolator/coupler, integrated circuit
Q1–Q3—TIL414 infrared phototransistor
Q4–Q6—2N2222 general-purpose NPN silicon transistor
DISP1—TL90063 LCD counter module (Radio Shack 277-302)
D1, D2—1N4001, 1-amp, 50-PIV, rectifier diode
LED1—Green light-emitting diode
LED2–LED4—SEP8703-1, or similar, infrared-emitting diode

RESISTORS

(All resistors are ¼-watt 5% units.)
R1—220,000-ohm
R2, R5–R9, R13, R14—10,000-ohm
R3—330-ohm
R4—15-ohm
R10—100,000-ohm
R11—56,000-ohm
R12—680-ohm
R15—220-ohm

CAPACITORS

C1—33-µF, 16-WVDC, electrolytic
C2, C5—4.7-µF, 16-WVDC, electrolytic
C3—0.001-µF ceramic-disc
C4—0.005-µF ceramic-disc
C6—0.001-µF monolithic

ADDTIONAL PARTS AND MATERIALS

BZ1—Piezo-electric buzzer element
K1—Subminiature, 5-volt, relay
Perfboard, fiber-optic cable, wire-wrap sockets, wire-wrap wire, solder, jumper wire, wood, etc.
Note: Fiber-optic cable is available from Circuit Specialist, Inc., PO Box 3047, Scottsdale, AZ 85271-3047 (Tel. 800-528-1417); and from Edmund Scientific, Co, 101 E. Gloucester Pike, Barrington, NJ 08007 (Tel. 609-573-6250 and 609 547-3488).

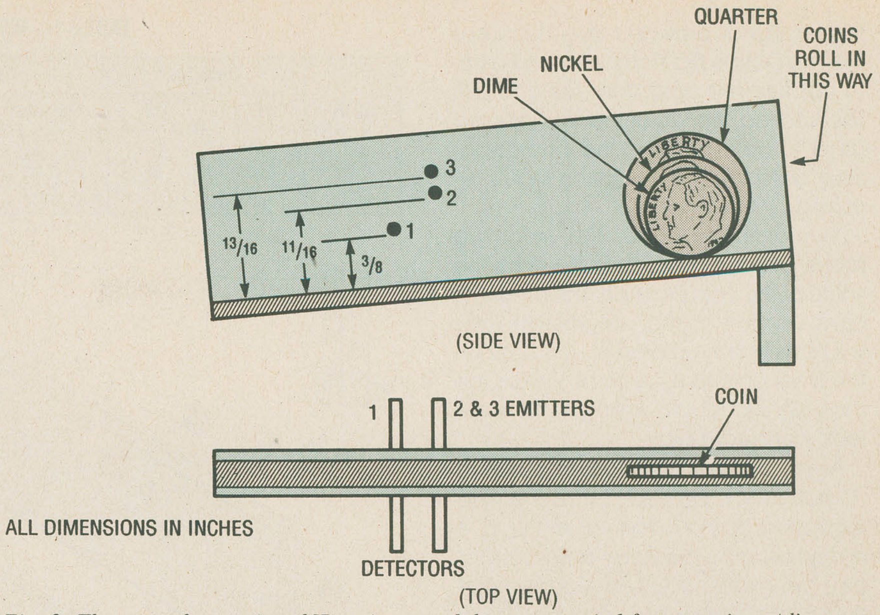


Fig. 2. There are three pairs of IR emitters and detectors: pair 1 forms a trigger/dime detector, pair 2 is for nickels, and pair 3 is for quarters.

preassembled counter with a built in 5-digit display. The two least-significant digits are used to represent cents, so it can display up to $999.99. When it counts, buzzer BZ1 beeps once for each cent, and can be reset to $000.00 by depressing S2. The display unit is decoupled by C6 to prevent noise problems. Counter/display module DISP1 is powered by B1 and, since it must keep track of the total, it remains on all the time. That is nothing to worry about, though, as it consumes only 3 µA.

The rest of the circuit does not receive continuous power. There is a power-saver circuit built into the unit that turns the rest of the circuit off if left idle. Cells B2–B4, when connected to the counter's battery (B1), form a 6-volt supply that is used to power the remainder of the circuit.

When S1 is depressed, it momentarily connects the positive side of B1 to the negative side of B2. That activates monostable U4-b (half of a 556 dual oscillator/timer). As you may know, to trigger such a monostable, there must be a negative pulse at the trigger input (pin 6). If you just tie that pin to ground, the monostable can't time-out. Since C2 is initially uncharged, it imitates a low and is allowed to slowly charge via R2 to allow the monostable to time out. The monostable turns on relay K1, which connects the cells together until the monostable times out. As you'll see though, the monostable is reset each time you feed the circuit a coin. LED1 indicates that the circuit is fully powered and ready.

When a coin is inserted into the coin slot of the bank, it rolls down a channel, or chute (see Fig. 2). On one side of the channel are three infrared LED's (LED2–LED4), and on the other side of the channel, directly opposite them, are three infrared-detecting phototransistors (Q1–Q3, respectively). Since the presence of infrared light turns the phototransistors on, they normally ground their pull-up resistors. Their collectors, thus, appear to be in the logic-0 state. If an LED is blocked by a coin in the channel, the collector of its corresponding phototransistor is pulled high by the pull-up resistor and generates a logic 1.

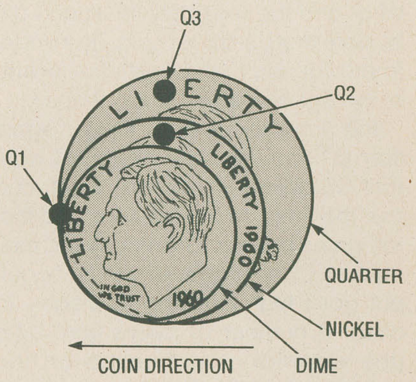


Fig. 3. Shown is the outline for the three coins detected by the circuit, and their relationship to the sensors. If your optics have trouble with cross-talk between Q2 and Q3, you can move Q3 further to the right.

The coin's size (and thus its value) determines which LED's get blocked (see Fig. 3). All coins block light to Q1, which is used to provide a trigger signal. The trigger signal is used to indicate that the coin is in the proper position to block the other two LED's as appropriate. If the coin is a dime, only LED2 is blocked, causing the collector of Q1 to go high; neither LED3 nor LED4 is blocked, so the collectors of Q2 and Q3 are low. A nickel blocks LED2 and LED3, so Q1 and Q2 are high and Q3 is low. A quarter blocks LED2–LED4, making Q1–Q3 go high.

Regardless of the coin's value, the

trigger signal provided by Q1 causes the two D-type flip-flops, U1-a and U1-b, to capture the data from Q2 and Q3. The latched outputs of the flip-flops are used to help convert the phototransistor data into the weighting inputs required by the timer (U3).

As mentioned earlier, the weighting factor needed for each coin will be the value of the coin plus one. The binary 1's complement of the weighting factor will have to be supplied to pins 8–12 on the timer chip to program it. Pin 8 is the most-significant bit, while pin 12 is the least-significant bit.

As you can see from Table 1, pin 11 of U3 can simply be tied low, as it is zero regardless of the coin's value. Pin 12 is always equal to the value of Q2. Pin 8 of U3 is the inverse of Q3. Pin 9 is the XOR of the two transistor values, and pin 10 is its inverse. Those logical relationships are maintained by the flips-flops (U1-a and U1-b) and the XOR gates (U2-a and U2-b). Note that U2-b is set up as an inverter to provide pin 10 of U3 with the inverse of the signal applied to pin 9 of U3.

The timer receives its trigger signal from Q1 via inverting transistor Q4. Note that C5 delays the action of Q4, and thus the timer, so the flip-flops and the XOR gates have a chance to set their outputs. Once triggered, the timer output goes high and the IC begins to count a number of pulses from U4-a (the external clock) based on the weighting-factor value.

The timer-output pulse does two things: First, it causes U2-d (which is used as a buffer) to turn on Q5. That transistor discharges the timing capacitor for the power-saver's monostable, effectively resetting it. Second, the timer output is inverted and sent to the reset input of U5 (multi-stage divider) at pin 11. The resulting low at pin 11 of U5 enables it, and it starts to divide the pulses from the external timer. When the timer goes low again, the reset input goes high, clearing any remainder and disabling U5.

The divided output is inverted by Q6, which operates optoisolator U6. The optoisolator ties the count pin of DISP1 high for each pulse, causing the counter to advance once for each cent.

Construction. Since few components are used in the circuit, it is the easiest

TABLE 1—WEIGHT-FACTOR LOGIC

	Detector		Weight (w)		Pin Input ($\overline{W}$)				
COIN	Q2	Q3	Decimal	Binary	8	9	10	11	12
5	1	0	6	0 0 1 1 0	1	1	0	0	1
10	0	0	11	0 1 0 1 1	1	0	1	0	0
25	1	1	26	1 1 0 1 0	0	0	1	0	1

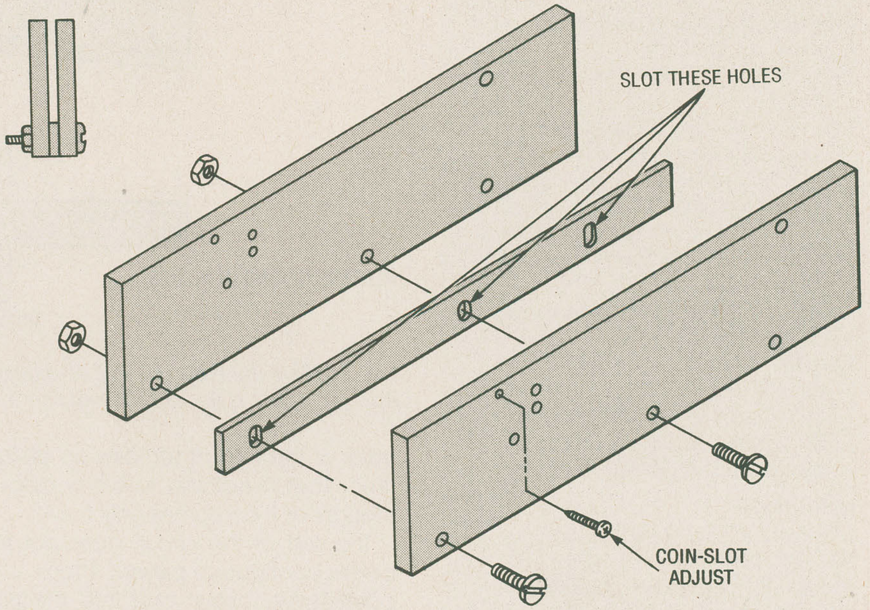


Fig. 5. The coin chute is made from two slats of wood with a narrow strip of wood in the middle, all held together with screws.

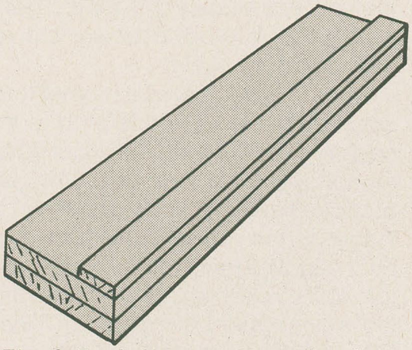


Fig. 6. Stack the wood on top of each other and tape them together to ensure that your drill holes will match up perfectly.

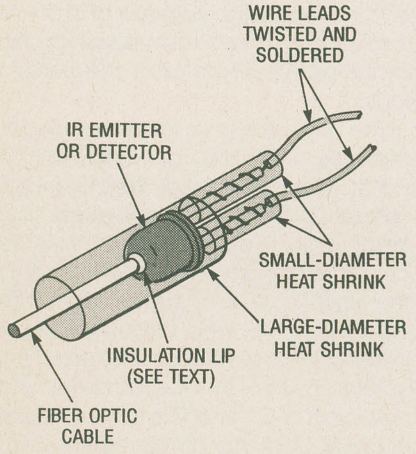


Fig. 4. Prepare the IR detectors and emitters as shown here. Note the lip faces the component.

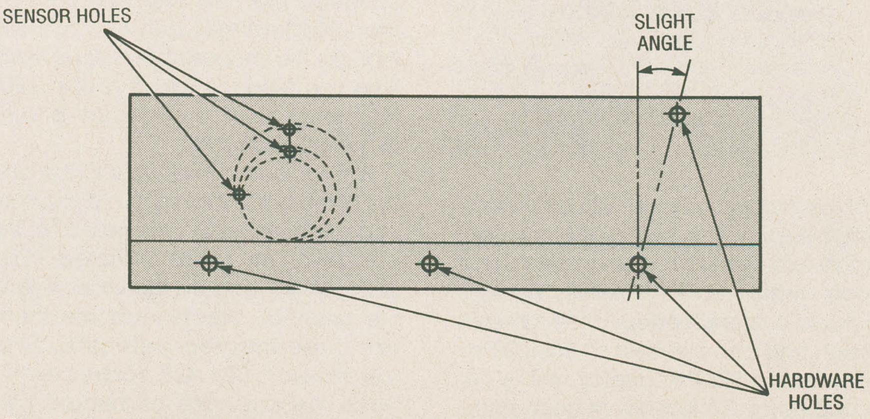


Fig. 7. Use this pattern as a drill guide for the coin chute. Be extra careful when drilling the sensor holes.

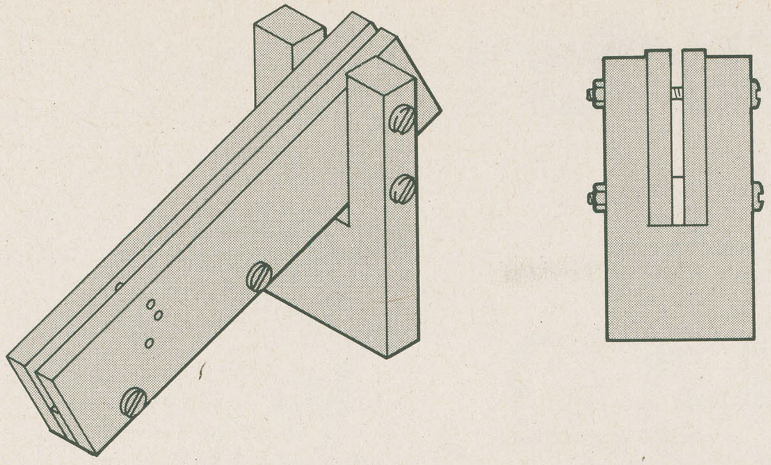


Fig. 8. Attach a U-shaped mounting bracket to the coin chute as shown. That makes installing the chute in the cabinet very easy.

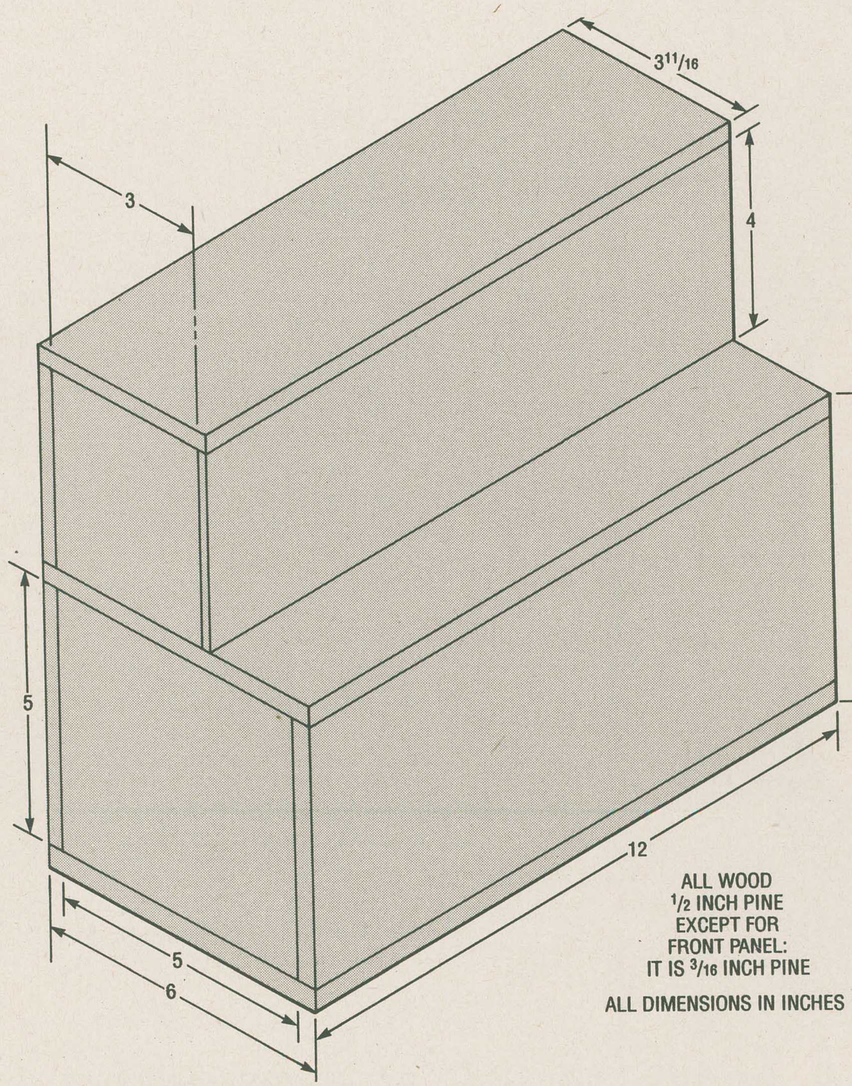


Fig. 9. These are the basic measurements of the cabinet. The top section is hinged to allow access to the bank's coin compartment and the reset button.

thing to build in the entire bank. Following Fig. 1, the connections are made using point-to-point wire-wrap techniques on a piece of perforated construction board. Be sure to use wire-wrap DIP sockets for all of the IC's. The connections to the board from the batteries, switches, etc., are made with insulated stranded wire soldered to the appropriate points on the board.

Note: Although a TI914 optoisolator/coupler is specified for U6 both in the Part List and the schematic diagram, almost any optocoupler that has a transistor output can be used.

You should supply leads for the IR detectors and emitters to be connected later on. You need one pair of leads for each phototransistor and one pair for all three emitters, since they are connected in series. Leave a little extra length on the wires for now; it's also a good idea to label each wire.

A problem came up in trying to figure out how to mount the IR detectors and emitters because their diameter is larger than the height difference between a nickel and a quarter. Fiber-optic cable solved the problem; its diameter is comparable to the height difference. Fiber-optic cable is available from several sources; two of those are given in the Parts List.

Prepare the IR detectors and emitters as shown in Fig. 4. Twist and solder a length of wire onto each lead, and cover with heat-shrink tubing. Using a sharp blade, cut a length of fiber-optic cable, leaving as flat a face as possible. Hold a match to one end of the fiber-optic cable for a moment; a lip will form around the insulation. Now, using wider heat-shrink tubing, affix the piece of fiber-optic cable to the end of the assembly with the insulation lip facing the component as shown.

It's best to build the coin chute now. Don't waste time trying to get the circuit to work with a test fixture, since you'll only have to build the chute anyway and it's very hard to get the detectors to work without the chute.

The chute was made from two slats of wood with a narrow strip of wood—a little wider than a quarter—acting as a separator and forming the bottom. All three pieces are held together with screws, and the holes in the bottom strip of wood are slotted to allow for fine coin-height adjustments (see Fig. 5). You can add an adjustment screw to the top of the coin slot to decrease the width of the slot if the sensors seem to be somewhat insensitive.

Once cut to size, the pieces of wood should be painted black. Stack the wood pieces on top of each other as shown in Fig. 6, and tape them together to keep them stable as you drill so that the holes will match up perfectly. Use Fig. 7 as a drill guide, and remember to slot the holes in the narrow piece.

The sensor holes should match the

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diameter of the fiber-optic cable for a snug fit, and the other holes should fit the hardware you're using.

Attach a U-shaped mounting bracket to the coin slot as shown in Fig. 8. Fit the emitter assemblies on one side of the coin slot and the detectors on the other. Now simply twist and solder them to the leads coming from the circuit board. Follow the polarity indications supplied with the exact parts you use in your circuit.

Make sure that the circuit is counting change properly before installing it inside a cabinet. Since this article is really about the electronics, we will not go into the details on how the cabinet was assembled, but the basic measurements are shown in Fig. 9. The electronic circuitry and the slot assembly mounts inside the top of the unit. The top and bottom half of the bank are attached with hinges to allow emptying of the change compartment and access to the reset button. The top half of the bank has a fairly large cutout in its base to allow the coins fall through into the bottom compartment. ■