MINI PLAYER PIANO

A liked the "Mini Player Piano" article in the September 1983 issue of **Radio-Electronics.** I would like to point out that some electrolytic capacitors were mislabeled in Fig. 4. (The Parts List is correct.)

I suggest some changes: Combine R30 and R40 for 1.2K ohms; eliminate R26, 27, 28 and the jumper there; eliminate ground connection to CC of center 7 segment display.

I have three of the 50240's and might try to use more than one octave. The clock oscillator for the 50240 will probably be variable in case of tuning with other instruments. I will do a lot of experimenting with that—maybe time it with clock of rhythm beat generators MM5871 or the 76477—if Spike Jones doesn't object.

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mini player-piano

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Build the Pianomatic and make beautiful music—electronically.

Part 3 This month we'll conclude our look at the pianomatic. Figure 17, the interconnection diagram that was discussed last time, appears on the following page.

The voltage regulator

Although voltage regulator IC13 is designed to output five volts, we can change that and make it provide 7.3 volts, a good operating voltage for the Pianomatic. By raising the ground terminal, pin 2 (C in Fig. 4, September issue) above system ground, we trick the regulator into putting out a higher voltage. Whenever you need a voltage slightly different than you can get from a standard series-regulator, that little trick can save you all sorts of design problems. Nothing is without a price, however. Certain circuit conditions, such as operating the regulator near the limit of its current capability, can cause the resistor at the ground terminal, R34 here, to overheat, change value, and change the regulated voltage. So make sure you heatsink the regulator and use a resistor of the proper wattage.

The maximum current-draw of the Pianomatic is about 100 mA at 7.3 volts, so it's not unreasonable to use batteries as a power supply. Remember though, that the voltage regulator, IC13, is a series regulator, and is not anywhere near 100% efficient. Although it will provide a steady output voltage, it requires an input voltage at least 2.5 volts higher than the desired regulated output. In the case of the Pianomatic, some elementary arithmetic tells us that we need at least $7.3 + 2.5 = 9.8$ volts for B1–B8. Eight alkaline cells provide us with $1.5 \times 8 =$

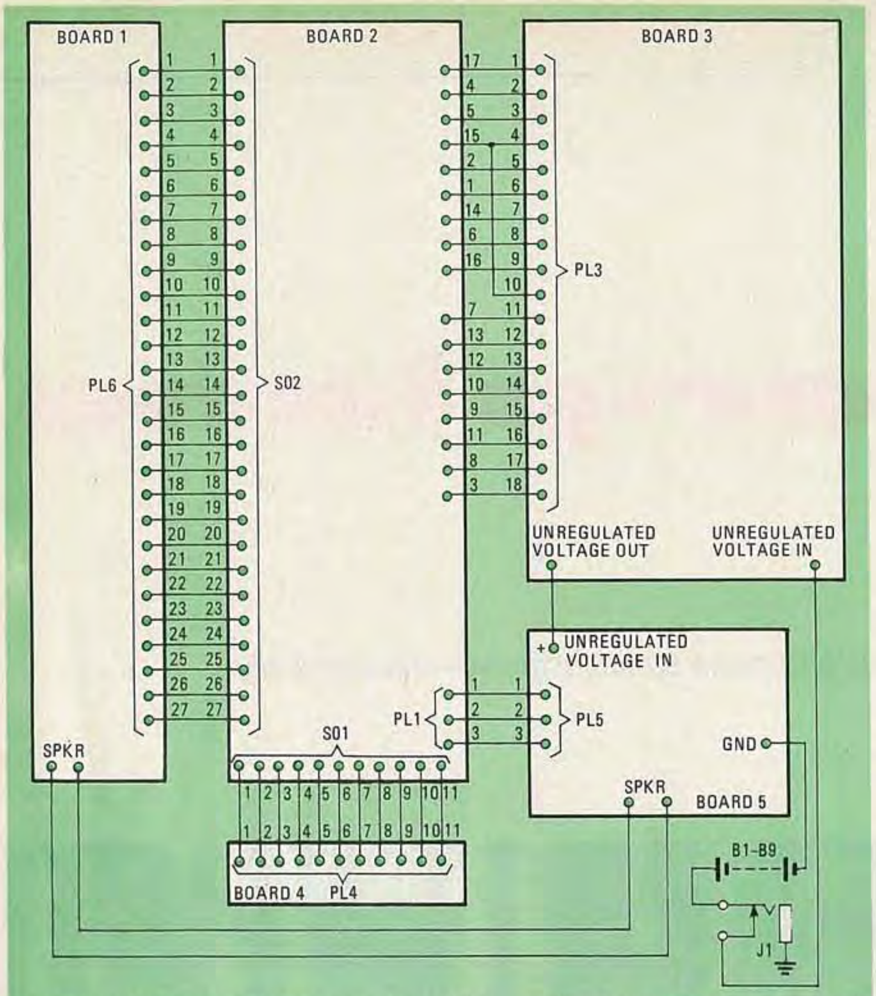

FIG. 17—HOW THE FIVE boards are interconnected. The connections between Boards 2 and 3 are also listed in Table 2.

12 volts nominally, and are a good choice. Since the current required is a maximum of 100 mA, "AA"-size cells are the smallest you should use. The inclusion of J1 in the circuit also makes it possible to power the Pianomatic from an external source such as a wall-plug transformer with a DC output.

If you decide to make a little nickel-cadmium pack for B9–B11, it's a great help to get button cells, or whatever, with solder lugs on them. Solder the cells together in series and then cover the package with a piece of heat-shrink tubing of the proper size as shown in Fig. 18. The PC pattern has space for three button cells with small pigtails of wire at the end to connect them to the board. If you use different cells, other provisions for mounting them will have to be made.

FIG. 18—BATTERIES B9-B11 should be button-cell types with solder lugs. Those batteries can then be soldered together, covered with heat-shrink tubing, and mounted directly on board 1 as shown.

Troubleshooting

In a system as complex as the Pianomatic, there are no simple ways to troubleshoot the circuit. If you make PC boards using the foil patterns provided, you won't have any electronic problems. Check for all the usual things—look for broken traces, unetched copper between the traces, bad solder joints or solder bridges, etc. If you suspect an electronic problem, do all the standard tests—are the clocks clocking, have I overlooked something incredibly basic, have I forgotten to apply power to the circuit, and so on. Check the polarities of the diodes and IC's against the placement diagrams. The last thing to check, the very last thing, are the IC's. Chances are that if an IC hasn't committed suicide and fried, there's nothing wrong with it. Wayward operation of an electronic circuit is usually due to a normal IC being fed schizophrenic data and doing its best to cope.

The connectors from board to board are male and female header strips made by AP, Sprague, and others. They come with standard 0.1-inch spacing, can be cut to any length you want, and are nice and cheap. One other nice thing about them is that they don't have to be mounted right on the edge of the board. That is a real advantage because digital boards are often topological nightmares. The male headers come either straight or right-angled, and both types are used in the construction of the Pianomatic. If you're really into saving money or don't ever expect to take the boards apart, you could hard-wire the boards together, but that is really a false saving. If you do use the connectors, be aware that they can be put

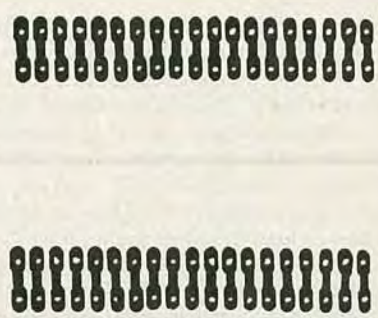

FIG. 19—FOIL PATTERN FOR HEADER STRIPS. The length of the board can be made as long or short as needed.

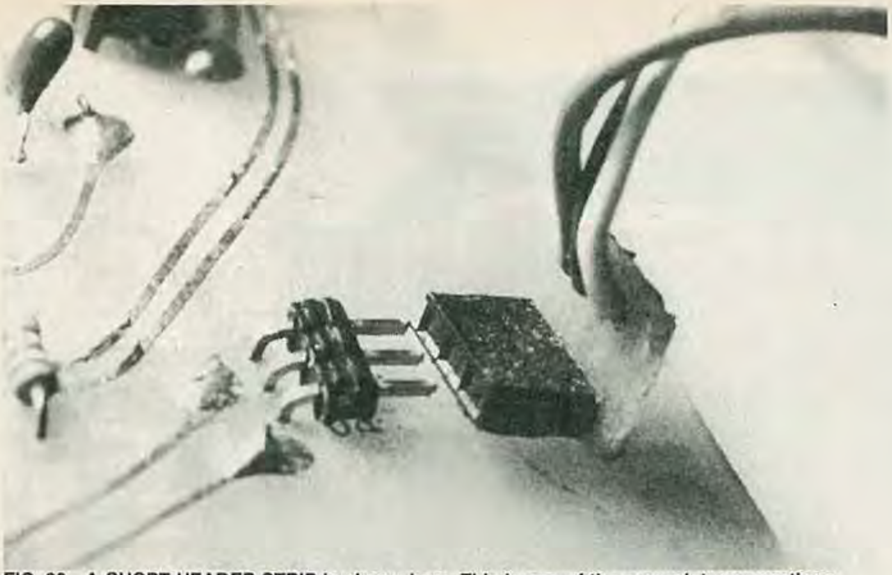

FIG. 20—A SHORT HEADER STRIP is shown here. This is one of the power interconnections.

at the end of a length of multi-conductor cable by making a small circuit board for them. A foil pattern for that is shown in Fig. 19 and you can see the construction in Fig. 20. The PC board can be made as long as you want depending on your need, and comes in handy when you have to deal with an oddball number of connections.

Calibration

The only calibration needed by the Pianomatic is the setting of the low-battery-warning trip point. Connect the Pianomatic to a variable power supply set to about 12 volts. Verify that the output of the voltage regulator, IC13, is 7.3 volts. If it's not, you'll have to change the value of R34. Raising the value will raise the voltage, and vice versa. Once you have the correct regulated voltage, lower the input voltage to 9.8 volts. Adjust R41 until the decimal points light in the display. If your decimal points lit when you supplied the twelve volts, disconnect the power and move the wiper of R41 closer to ground. When you turn the power back on, the decimal points will be out and you can then calibrate the trip point of the circuit.

One point about those displays. You'll note that they have 10 pins, but that there are only 9 mounting pads on the PC board for each. The reason for that is that pin 1 is a second common-cathode connection and is not needed. Thus, that pin can be unused without affecting operation. To keep things simple, it is cut off, eliminating the need for one of the mounting pads.

Use

The Pianomatic is very easy to use. With the control switches set to WRITE, MANUAL, and MEMORY, the display counter should be all zeros. Every time you press a key, you will hear the corresponding note and the LED in the key will light. When you release the key, the display counter will increment by one to show you which note position you are programming next and the LED corresponding to the next note in memory will light up. If you make a mistake in programming, don't worry because the Pianomatic is very easy to correct later on. After you've programmed the entire tune, push the RESET button, S6, to get back to the beginning of the page. Put the READ/WRITE switch, S2, in the READ position, and single step through the tune in MANUAL playback. If you come across an error, put S2 in WRITE and program the correct note—that's all there is to it.

There are 16 switches on the keyboard. Switches S10–S22 are used to program notes. To program a rest, S9 is used. Switch S23 is used to program a half rest (binary 14). Finally, S24 is used to enter a binary 15 (tune end) on the bus.

It's a good idea to program in a rest for the first note in a tune (the note that occupies the position shown in the note-counter display as 000), since the Pianomatic will automatically reset to that position when you are playing back a tune in AUTOMATIC. Remember that the last thing you have to program in a tune is a binary 15 (tune end). The Pianomatic will decode that and stop playing.

The Pianomatic doesn't understand the difference between a quarter, half, or whole note. If the tune you are programming requires a note to be held for three beats, you'll have to program it in three successive addresses in the memory. Although you will be playing back three notes, the transition between them is so smooth that you won't hear any interruption. Likewise, because of that smooth transition, if you want a fresh attack on a note, you'll have to program in a half rest (binary 14) before it.

The blanking of the displays and the counter resetting is handled automatically by the circuitry in the Pianomatic. If you feel that you want to change any of it, you'll have to rewire some of the switches (for the display blanking), or remove some components (for resetting the counters). For instance, the Pianomatic resets the counters to zero when you switch from WRITE to READ. If you wanted to defeat that you would have to remove D2 and C6. If you find that you want to eliminate any of the automatic control functions of the Pianomatic, study the schematic, locate the relevant parts, and take them off the board.

Table 1 (in the September issue) describes the control functions of the switches and gives you a good idea how to go about changing anything you want. Remember that none of those functions are sacrosanct. The circuit and its operation are interesting enough to teach you a lot of things if you're willing to spend the time playing "What if?"

Before you go about changing things, however, make sure your Pianomatic is working, and that you understand the information in Table 1. The effects of the switches are all interrelated and putting the Pianomatic in any particular mode of operation may require the throwing of several switches. As you can see from Table 1, the keyboard is disabled in AUTOMATIC playback. This means that if you want to use the keyboard, switch S3 must be in the MANUAL position. That is true regardless of how the other switches are set. The same sort of reasoning applies to the other functions of the Pianomatic. If you go over Table 1—carefully—you'll see what has to be done to change any of those things.

Case

A plastic piano-shaped case was built for the Pianomatic; the control switches (board 3) were located in the bench and B1–B8 were located in the wood box on which everything else was mounted (see Fig. 21). Obviously that isn't necessary—the Pianomatic can be put in any standard box large enough to accommodate the boards, batteries, etc. If you decide to make a fancy case for your Pianomatic, or even just a piano-like keyboard, here is some straight-from-the-shoulder advice—try to find a toy electronic piano that has a keyboard of the right size, cannibalize the toy, and use the keyboard. The prototype was built using microswitches for switches S9–S24, and it was an extraordinary amount of work. If you use a toy piano, the only alteration you'll probably have to make is to drill the holes in the keys for the LED's.

As you can see from the foil pattern for Board 5 (Fig. 11), the board was designed to fit in the rear of the piano-shaped case. The speaker was mounted on the rear of the board and small lengths of wire were used to connect it to the speaker terminals on Board 1. If you decide to go that route, drill a hole in the rear of Board 5 and

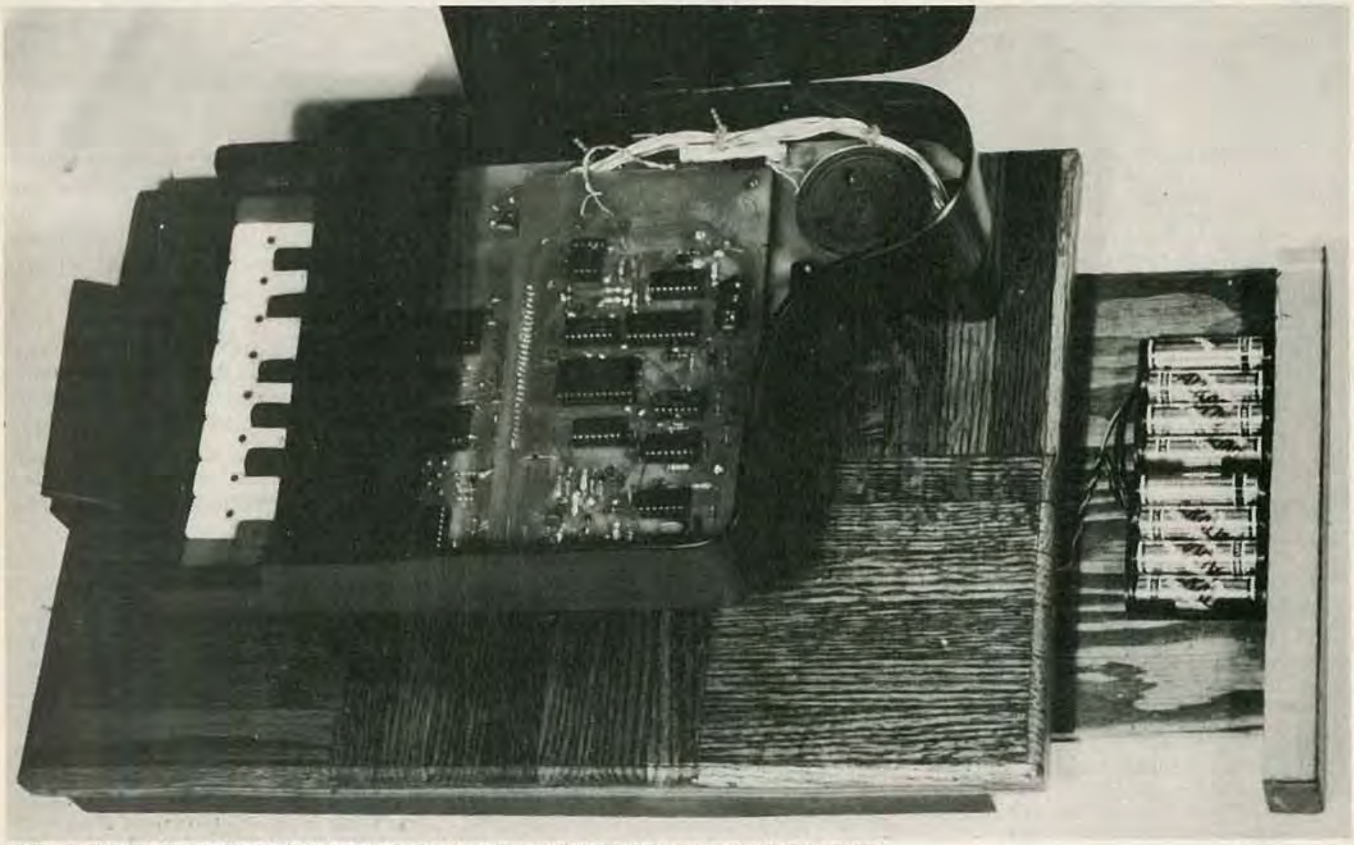

FIG. 21—THE COMPLETED PIANOMATIC. The "piano" case and "bench" were mounted on a wood base in the author's prototype shown here.

slowly enlarge it until the speaker's magnet housing fits snugly in the hole.

The note-counter display board, Board 4, is laid out so that the display digits will sit in the middle of the keyboard. Right-angled male headers on Board 4 are used as the connectors and the entire board plugs into the appropriate strip of female headers on Board 2.

Just as an aside, some of you might wonder why a 4514 was used for IC1 and a 4515 for IC6. The difference between them is only in the polarity of their outputs—otherwise they're pin-for-pin identical. The answer is very simple—one of each was on hand so they were used. The reason had more to do with inertia than anything else.

Expansion

The Pianomatic is designed to play a total of 256 notes, and only one note at a time. If you want to expand on those things, you'll have to expand the memory. If you want longer tunes, you'll have to have a memory that can handle more words. If you want to increase the range of the Pianomatic you're going to have to increase the amount of data in each word—you'll need a wider bus.

One extra bit on the data bus will enable you to insert a programmable divide-by-two network between the note generator and its clock. By doing that you can add an entire octave to the range of the Pianomatic—two extra bits and you'll get four octaves, and so on. All that's necessary to shift an octave is to divide the frequency going into the clock input of IC7. If you want to be able to play more than one note at a time, you're going to need a separate bit for each note in the octave. That means you'll need a data bus at least thirteen bits wide—a sixteen-bit bus would give you all the notes playing individually, four or more octaves, and still leave room for programmable voicing, tremolo, and so on. The only change you'll have to make in the circuitry, other than the memory, is to have a separate 50240 for each octave and a separate analog switch for each note. The last word of caution is to remember that the outputs of the note generator, IC7, cannot be connected directly together. You will have to sum them with resistors and then feed the common legs of the resistors to the input of the amplifier.

Although the Pianomatic was designed as a programmable music box, it can be used as a doorbell, alarm, telephone ringer, or anything else you can think of. By replacing the START switch, S4, with a small relay, just about any type of signal can make it play. A little bit of ingenuity on your part will easily produce a substitute for the tune selector so that different signals (doorbells on different doors, for example) will trigger different tunes. The range of applications is limitless.

A set of the five PC boards, etched and drilled, but not plated through, is available from Hal-Tronix, PO Box 1101, Southgate, MI 48195. The price is $39.95. Please add $2.00 for shipping and handling. MI residents add 4% tax.

Any construction project should also serve as a learning experience, and the Pianomatic has a lot to teach you. It uses circuit techniques that can be adopted for your own designs. It should make you think of variations in applying the principles of operation so your own projects become more and more sophisticated. Low-power memory retention and keyboard encoding are only a few of the things you can learn by understanding the operation of the Pianomatic. **R-E**

"There's something wrong with this digital readout. It's nothing but a bunch of numbers."