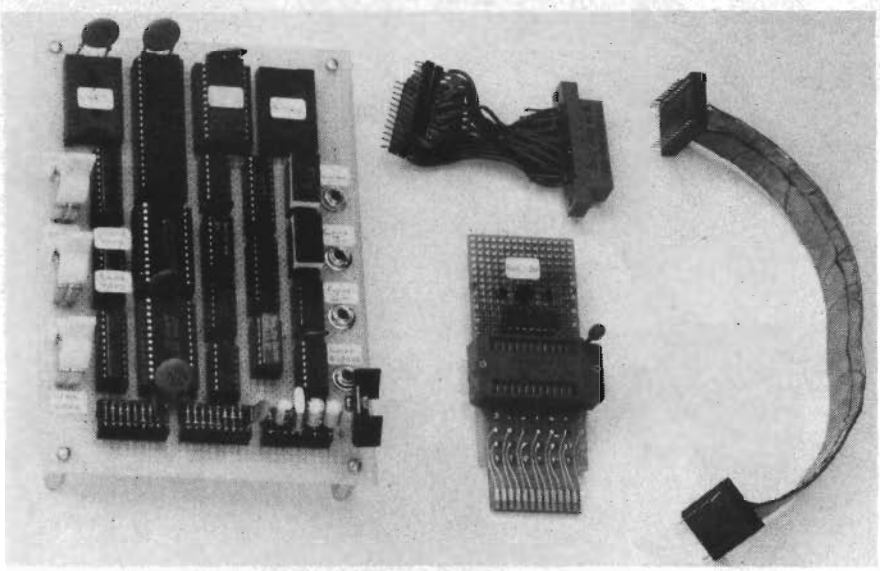
ATARI Game Recorder

GUY VACHON and DAVID A. CHAN



You can record the contents of your Atari 2600 videogame cartridges on audio cassette tape! This month, in the conclusion of this article, we'll show you how to build the game recorder and how to put it to use.

Part 3 WHEN WE LEFT OFF last time, we were describing the memory mapping technique that the game recorder uses. The last thing that we want to mention on that subject is that, for simplicity's sake, all ROM's were treated as if they were 4K × 8. That doesn't present any problems with 2K × 8 ROM's because they ignore the most-significant address bit. However, we end up with two copies of the cartridge in the 4K × 8 space—the top and bottom halves are identical. For the time being, remember that all 2K × 8 and 4K × 8 ROM's can be read by inputting to the ROM 4096 addresses (all that can be obtained from all possible combinations of 12 address bits), and saving the data patterns that the ROM returns.

One of the goals of the design of the game recorder was to keep the IC count down. Therefore, the extra memory IC's that would be required to make room for the system stack were not added. That conflicted with our desire to use subroutines (whose return addresses are usually stored in the stack). To get around that conflict, return addresses are kept in the Z80's internal registers. Thus, before a subroutine is called, the return address desired is stored in an internal register; the particular register is determined by which subroutine is to be called. The number of Z80 registers allows for up to three levels of subroutines. Besides that "trick," the software that we showed you last month is quite straightforward.

Building the game recorder

The author's prototype, shown in Fig. 6, was built on perforated construction board. Most of the connections were wire-wrapped. (Even the discrete components were wire-wrapped by first installing them in DIP headers, and then installing the header in a wire-wrap socket.) Eighth-inch phone jacks were used for cassette I/O and power connections, and 24-pin DIP sockets were used for connections to the Atari *2600* and to the game cartridge. Note that a simple power supply, whose schematic is shown in Fig. 7, was also mounted on board. The input to the supply is from a 9-volt, 500-mA DC wall transformer—similar to the transformer that the Atari *2600* itself uses.

Turning to Fig. 8, we see the connectors we need to connect the main board to the game cartridge and to the Atari *2600*. At the top left is the cartridge connector. In the author's prototype, that was basically a DIP-to-card-edge converter: One side plugs into the 24-pin DIP socket on the main board, while the other side is a 24-pin card-edge connector with standard 0.1-inch spacing. Note that to make wiring the connector easier, two 12-pin jumper headers are used to plug into the 24-pin socket. The wires from the headers then connect to the 24-pin edge connector. If you look closely at the photograph, you might note that an inverter is mounted between the socket and the card-edge connector. That's needed to invert the ENABLE line because the program ROM in the cartridge—as opposed to a 4K EPROM—is active high. The foil patterns that we'll show you shortly incorporate the inverter on the board.

Below the cartridge connector is a second board—which we'll call the *adapter board*—that is needed to connect the

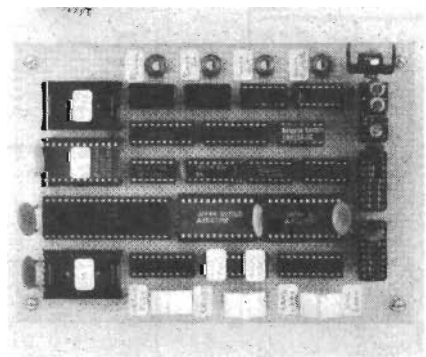


FIG. 6—THE MAIN BOARD of the author's prototype. Three SPDT switches, two 24-pin sockets, and 3¼-inch phone jacks are used for input/output. The fourth jack is used for connection to a wall transformer.

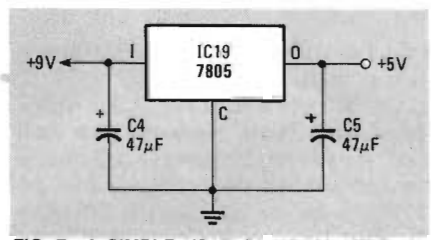


FIG. 7—A SIMPLE VOLTAGE REGULATOR circuit can be mounted on the main board.

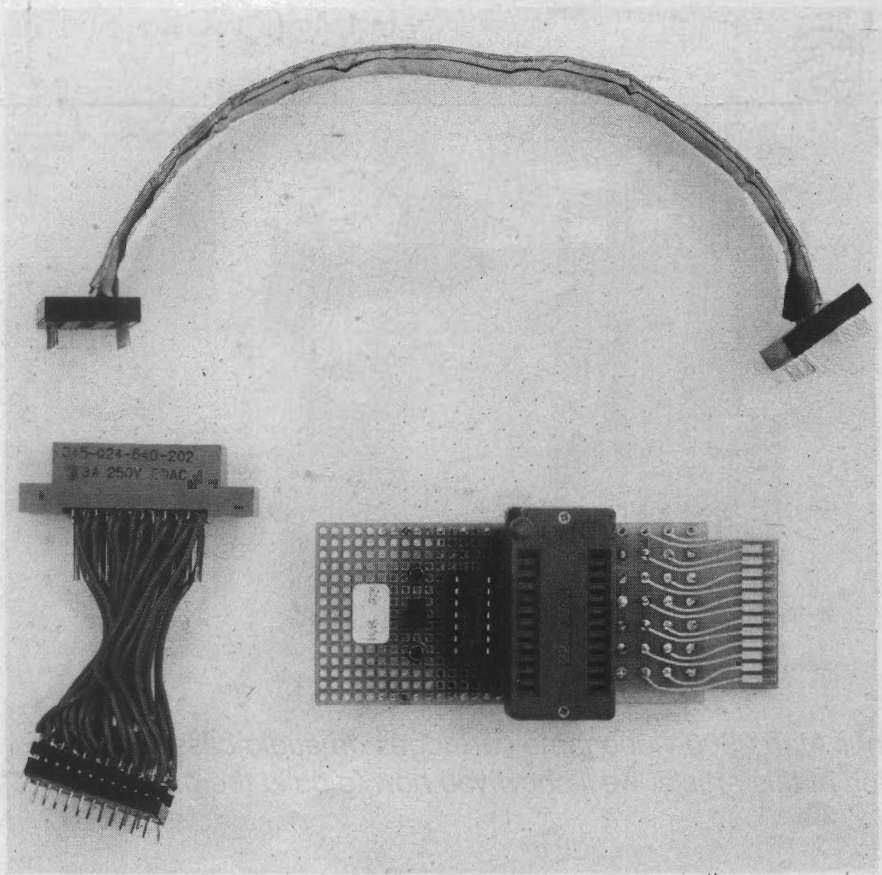


FIG. 8—TO CONNECT THE MAIN BOARD to the Atari *2600* and to the game cartridges, you need to make up special connectors.

main board to the *2600*. Note that there is also an inverter on that board.

On the right side of Fig. 8 is a ribbon cable with 24-pin connectors on each side. As you might have guessed, that is used to connect the main board to the *2600* (via the second board). A ZIF (Zero *I*nsertion *F*orce) socket is mounted on the second board for convenience. Note that the ribbon cable is shielded by copper foil. You will most likely find that shielding the cable will be necessary.

Wire-wrapping a circuit of this complexity is possible but, since wire wrapping sometimes leads to problems in troubleshooting and in mechanical integrity, a printed-circuit board is a desirable alternative. Foil patterns for the component and solder sides of the main board are shown in Figs. 9 and 10 respectively. A supplier of that board is available: See the parts list for information.

The parts-placement diagram for the main board is shown in Fig. 11. Note that there are a few differences between the PC board and the author's prototype. For example, while all the switches and jacks were mounted on the main board of the prototype, the PC board is meant to be used with panel-mounted components. Also, the inverters that were mounted on the prototype's connectors are now located on the board. Note that pull-up resistors for some of the switches are locted off-board. Those resistors, which were not shown in the schematic, are shown in Fig. 11.

You will still need an adapter board to connect main board to the *2600*, and you will have to wire up special cables to connect the main board to both the *2600* and to the game cartridge. The foil patterns for the adapter are shown in Figs. 12 and 13. Figure 14 shows the card-edge pinout of a game cartridge. That, along with Figs. 11–13 should help you wire your cables correctly.

When you build the game recorder—or any other device that uses IC's—be sure to use IC sockets. Start by installing those sockets, followed by the discrete components. Don't install any of the IC's except the voltage regulator. If you use a wall-mounted transformer, install an 1/8-inch phone jack off the board for power connections. Apply power to that jack and check for +5 volts at the appropriate IC pins. Remove power and double check the board for shorts between traces (solder bridges) or for any other potential problems. When you're confident that the board is in good shape, install the IC's, the two displays, and the relay.

Next, you'll have to install the other jacks and the switches. Since those are meant to be panel-mounted, you'll have to cut wires to the appropriate length. Once that is done, you're ready to test the unit out.

Using the game recorder

Throughout this article, we've referred to the various switches and displays that are used on the game recorder. Now it's time to tell you how to use them.

Six switches, two seven-segment displays, and three phone jacks are used for input and output to the game recorder. If you look at the photo in Fig. 6, you'll see only three switches—each single-pole, double-throw switch is used for two functions. You may want to follow the same setup: After all, you can't read and write to the cassette tape at the same time!

Let's give a brief overview of what the switches and displays do. Then we'll go

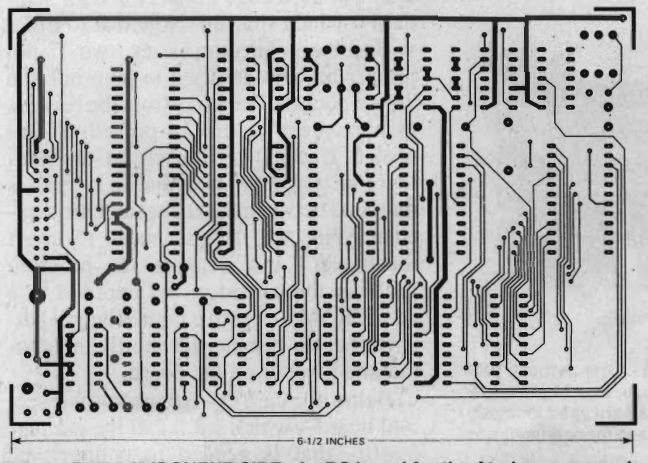


FIG. 9—THE COMPONENT SIDE of a PC board for the Atari game recorder.

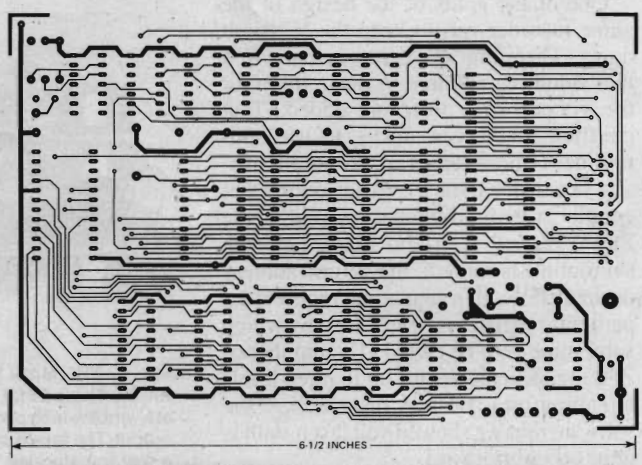


FIG. 10—THE SOLDER SIDE of the game recorder board.

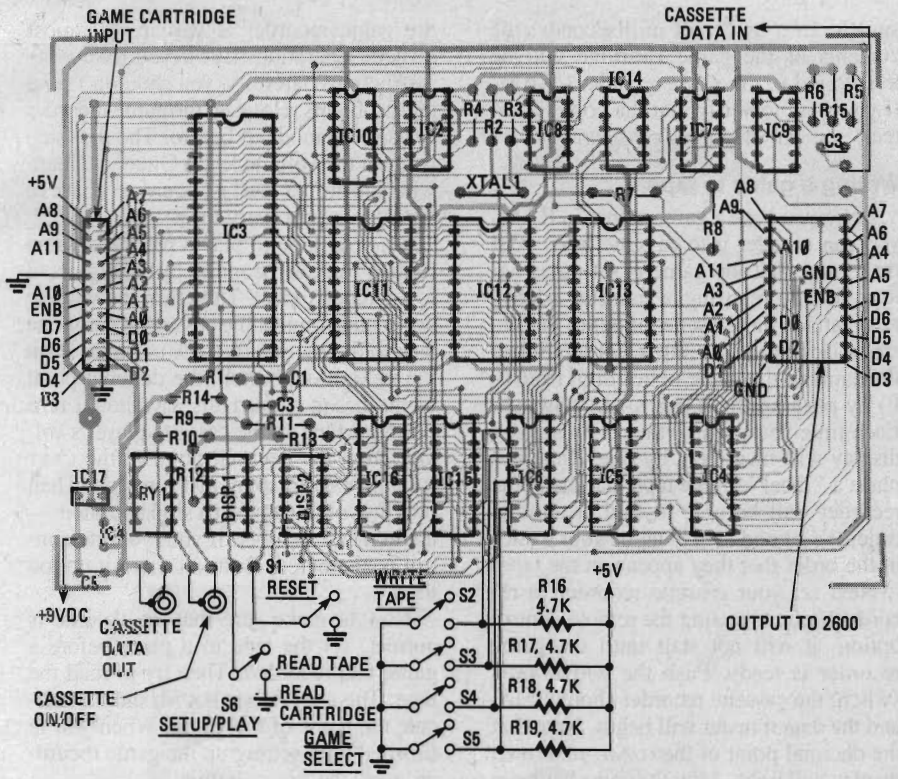


FIG. 11—PARTS-PLACEMENT DIAGRAM for the main board. Note the connector pinouts. You will have to wire up a cable to connect the main board to game cartridges and to the adapter board.

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise specified.
R1—220,000 ohms
R2, R3—1000 ohms
R4—330 ohms
R5, R7–R9—10,000 ohms
R6, R15—100,000 ohms
R10—3300 ohms
R11—47,000 ohms
R12, R13—120 ohms
R14—4700 ohms

Capacitors
C1—1 µF, 10 volts, electrolytic
C2, C3—.01 µF, ceramic disc
C4, C5—47 µF, 10 volts, electrolytic

Semiconductors
IC1, IC8, IC14—74LS00 quad 2-input NAND gate
IC2—74LS74 dual D-type flip-flop
IC3—Z80 microprocessor
IC4–IC6—74LS244 octal buffer
IC7—74LS125 quad bus buffer
IC9—LM3900 quad op-amp
IC10—74LS138 3-to-8 line decoder
IC11—2716 EPROM containing the computer's operating system
IC12, IC13—2016 2K × 8 static RAM
IC15, IC16—74LS273 octal D-type flip-flop
IC17—7805 5-volt regulator
DISP1, DISP2—MAN74A or similar seven-segment display

Other components
S1–S5—SPST momentary switch
S6—SPST toggle switch
Miscellaneous: 12½ card-edge connector, ZIF socket, wiring harnesses to connect main board to *2600* and cartridge, etc.

An EPROM containing the game-recorder program is available for $15 postpaid from J&L Associates, 1133 Broadway Room 906, New York, NY 10010. New York residents must add sales tax.

A set of two etched, drilled, and plated-through boards are available from E²VSI, PO Box 72100, Roselle, IL 60172 for $32.50 postpaid.

into detail on each function. The first switch we'll consider is the GAME SELECT switch, S1, which is used to reset the game recorder in case of failure. The WRITE TAPE switch, S2, is used to initiate the transfer of data from the game recorder's RAM to a cassette tape. Switch S3, READ TAPE, does just the opposite: It initiates data transfer from cassette tape to the game recorder's RAM. The READ CARTRIDGE switch, S4, initiates the transfer of data from the game cartridge to the game recorder's RAM. Switch S5, GAME SELECT, is used to select the name of the game that you want to save on tape, or the name of the game you want to find on a tape. You have 16 choices for a name: the hexadecimal digits Ø–F. The final switch, S6, is the SETUP/PLAY switch which is used to put the game recorder in the mode to play a game on the *2600*.

The first of the two displays, GAME SELECT, shows the name of the game that you want to save or the one you are trying to find on a tape. The name is selected by the GAME SELECT switch. The LAST GAME FOUND display is used to indicate the name of the game that the recorder is "listening to" on the tape. We'll see that the decimal points of those displays serve another important function.

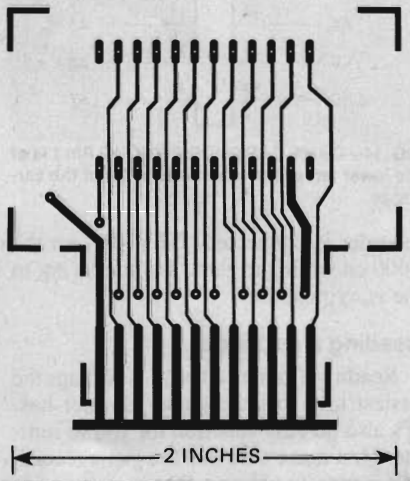


FIG. 12—THIS ADAPTER BOARD is used to connect the main board to the Atari *2600*. We recommend that you use a DIP socket for convenience.

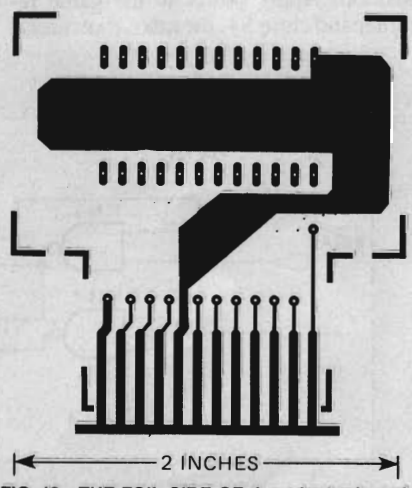


FIG. 13—THE FOIL SIDE OF the adapter board.

There is one cassette input to the game recorder (CASSETTE DATA IN) and two cassette outputs (CASSETTE DATA OUT and CASSETTE ON/OFF). Note that the schematic does not show the CASSETTE ON/OFF output. Instead, the output of IC7-c is labeled "TO CASSETTE-CONTROL RELAY." Although the relay is not shown on the schematic, the board has provision for a DIP mounted relay that can be controlled by the output of IC7-c.

Before you use your game recorder, keep the following notes of caution in mind: **NEVER** plug a game cartridge in while the game recorder is on. The *2600* should be turned **OFF** before the game

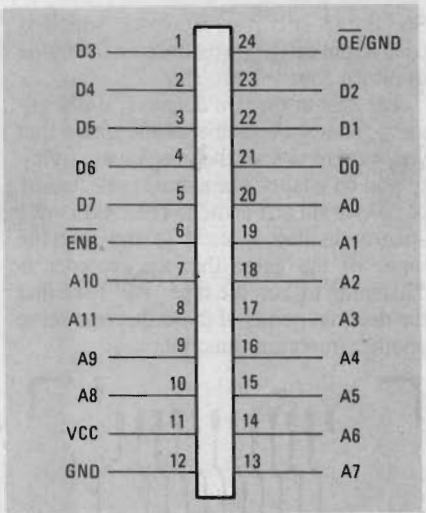


FIG. 14—GAME CARTRIDGE PINOUT. Pin 1 is at the lower left of the front (label side) of the cartridge.

recorder is connected. **NEVER** turn the *2600* on while the game recorder is not in the PLAY position.

Reading a cartridge

Reading a game cartridge is perhaps the easiest task that the game recorder has. It's also an easy function for you to initiate. First make sure that the game recorder's power is off and that it is properly hooked up to the *2600*. Then make sure that the SETUP/PLAY switch is in its SETUP position. Apply power to the game recorder and close S4, the READ CARTRIDGE switch. In a matter of milliseconds, the contents of the game cartridge will be transferred to the game recorder's RAM. If you want to verify that the copy is correct, you can play the game.

Writing a game to tape

Once you have a game stored in RAM, you can transfer it to cassette tape. First make sure that the game is set up as before. If you're using a cassette control relay, attach the cassette output to the REMOTE jack of the cassette recorder. Select the name of the game (a hex digit from Ø-F) by pushing the GAME SELECT switch. Each time you push it, the GAME SELECT display will increment by one. That will place a "label" on the tape that the game recorder will be able to find at another time. It's a good idea to name your games in the order that they appear on the tape.

Next set your cassette recorder to record. (If you are using the remote control option, it will not start until the game recorder is ready. Push the WRITE TAPE switch; the cassette recorder should start, and the data transfer will begin. Note that the decimal point of the GAME SELECTED display will light. After the game has been transferred, the decimal point will again go dark. That's your signal to stop your cassette recorder if you're not using the remote control option.

Reading a tape

Loading a game from cassette tape to the game recorder is perhaps the most difficult operation. But if you follow the instructions carefully, you shouldn't have any problems. Hook up the game recorder in its setup mode as before. The first step is to set the volume level. Once you learn what the proper level is, you won't have to repeat this step every time.

Set your tape to play a recorded game (which you can recognize by the high- and low-pitched tones). Then turn the volume down and connect the cassette's earphone jack to the CASSETTE-DATA IN input. Push the READ TAPE button; the decimal point of the GAME SELECT display should turn on. Now turn up the cassette player's volume until the decimal point of the LAST GAME FOUND display just turns on. Then turn the volume up just a slight bit more—about a half number, if your volume control is numbered. But don't turn it up too loud.

Now to make sure that the volume is correct, set the tape to a place before a game you recorded. Then try to read the tape. The LAST GAME FOUND should indicate the name of the game. When you're finished with setting up the game recorder, press the RESET button.

Now try to load back a game you recorded by selecting its name, setting up the recorder, and hitting the read tape button. The LAST GAME FOUND display will indicate the name of each game the game recorder finds. When it finds the selected game, it will read it and stop the cassette player when it's finished (if the remote option is used).

Playing a game

Now that you have a game in the game recorder's memory—either from a tape or from a game cartridge—you can play it on the *2600*. Just move the SETUP/PLAY switch to the PLAY position and turn the *2600* on. Your game should be ready to play. Be sure to turn the *2600* off before moving the SETUP/PLAY switch back to SETUP.

Expanding the game recorder

As a final note, we should note that many new games for the Atari *2600* are 8K long. The basic ideas of this game recorder can be used to record those games on cassette tape. However, you will have to make both hardware and software modifications. We won't go into detail on how those modifications are made, but we will give you a head start.

Figure 15 shows one way of adding to the the address decoder to obtain bankswitching ability. The software would have to be written to turn the memory-mapped bankswitching mechanism on and off (by setting and resetting a flip-flop, for example). The software should include some way to detect and record the ROM size. The last two bits of the header could be used for that purpose. **R-E**

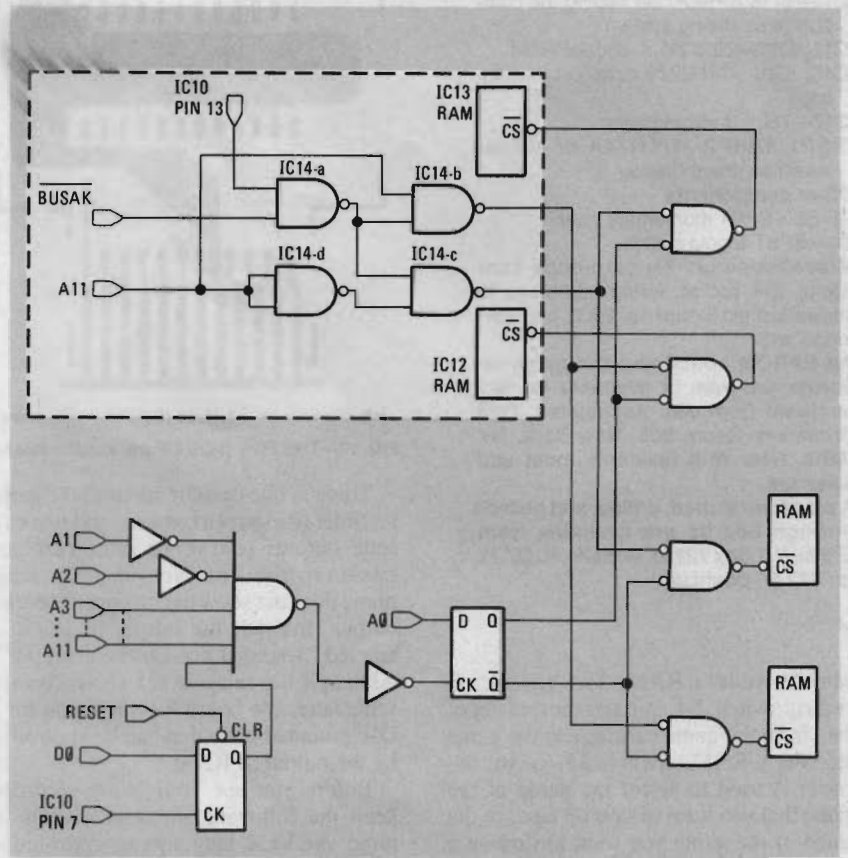


FIG. 15—EXPANDING THE RECORDER to record larger games is possible. The software will have to be changed, as will the address decoder. Here is a possible decoder scheme to use for bankswitching.