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Electronics: beating us at our own games

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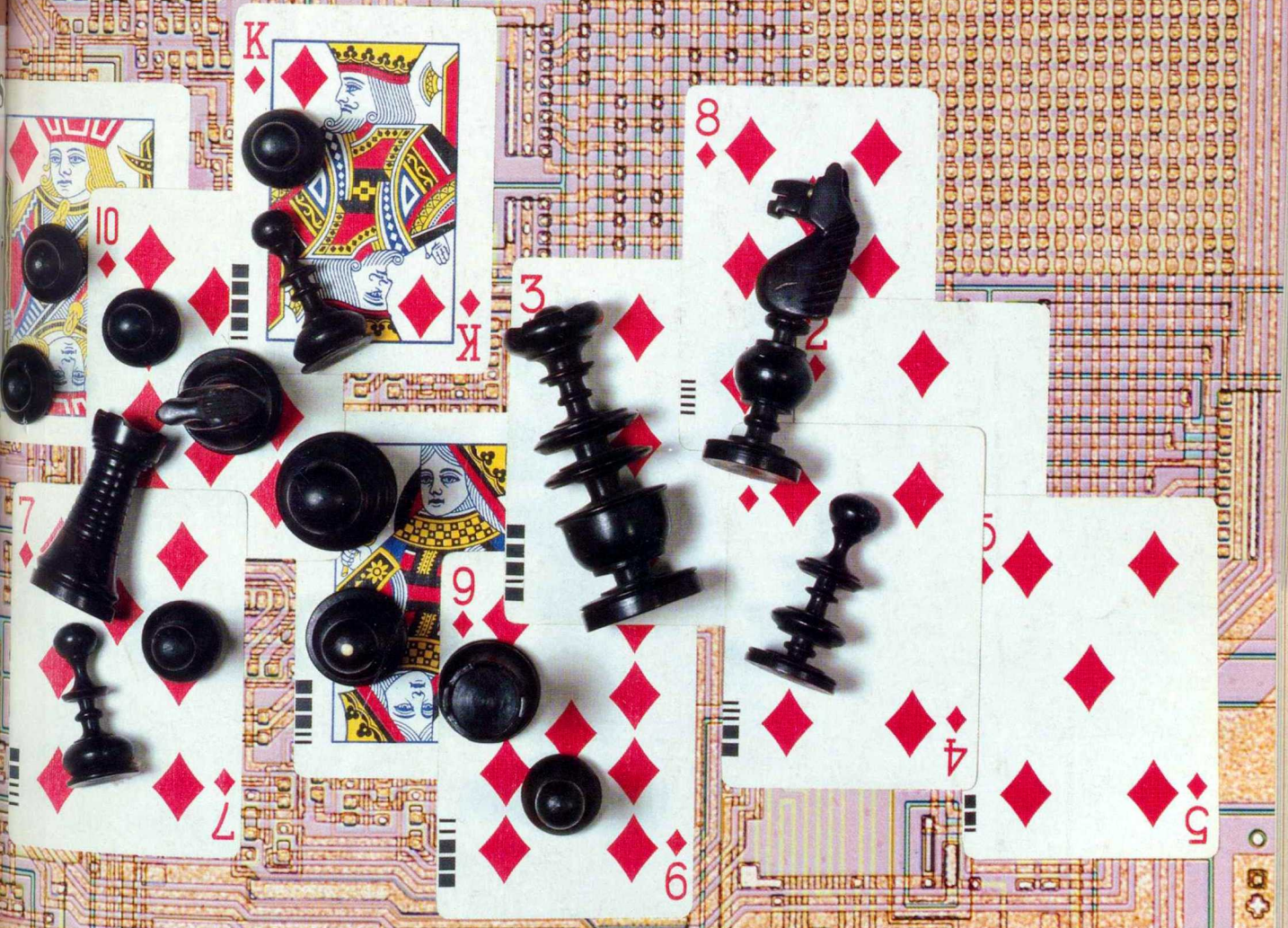

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the cover

Fisher-Price's random-talker doll contains the speech synthesis circuit pictured in the background. It was made by Precision Monolithics Inc. from a design by Fisher-Price and Siltronics Inc. The playing cards are magnetically coded for Tryom's bridge playing game. Suit and value are stored in RAM for future plays and bids. The chess pieces are not electronic. For more on electronics in toys and games, see page 26.

Beating an electronic opponent is a challenge

But the road from the concept of an intelligent game to the final product is both challenging and tortuous

Got an idea for an intelligent electronic game? It will take more than convincing a game manufacturer to bring it to fruition. It took Gary O'Hara and Tim Shane seven years before their highly successful backgammon game, Gammonmaster, landed on department store shelves. The long turnaround wasn't due only to engineering problems, but rather because of such uncertain factors as cost/performance trade-offs, market acceptance, and competition from other game vendors and other television video games.

Despite these obstacles Tryom Inc., the small company Mr. O'Hara and Mr. Shane founded in 1975 in Beachwood, Ohio, is starting to reap profits from its labors. Although still too highly priced for popular consumption, Tryom games have been selling well to the well-to-do. The games include chess, bridge, and backgammon.

Another company faring as well is Fidelity Electronics Ltd. of Miami, Fla. It was the first out with an electronic chess game, and it has added bells and whistles to each new model. The latest addition is a speech function that prompts players during the game.

At both companies, the design was done by a few persons with creative ideas. Such an individual must be simultaneously a hardware and software specialist, a packaging expert, and a systems engineer who oversees the project from concept to conclusion.

This is a story of two entrepreneurs who tried and were successful.

Gary O'Hara met Tim Shane at a midwestern university. Mr. O'Hara was finishing his thesis for a master's degree in computer science, specializing in artificial intelligence. Mr. Shane was completing his studies in business administration. The combination was a natural that led to their first venture—an electronic backgammon game.

Capitalizing on a popular game

"Backgammon just started gaining in popularity in 1971," says Mr. O'Hara, now vice president of research and development of Tryom, "and the same year the first 8-b microprocessors became commercially available." Mr. O'Hara and Mr. Shane started collaborating and in 1975 incorporated Tryom in Beachwood, Ohio. They put their first hand-held Gammonmaster backgammon game on the market at the June 1977 Consumer Electronics Show. That same year Fidelity Electronics of Miami, Fla., a former manufacturer of medical electronic equipment, had introduced an electronic chess game called Challenger. Since then, it's been neck and neck between these sole contenders in self-contained "intelligent" games.

For the two founders of Tryom, it was a long, hard but immensely exciting road from concept to the finish line. Mr. O'Hara says that "at all steps of the way we were never sure that what we had would actually sell." Moving into what is essentially a very volatile toy and game industry, they had to play by its rules—namely, they had to predict the consumers' response, a flaky variable that depends on instant preference and available discretionary spending.

Hand-held electronic sport games were also hitting the market in 1977, but their electronics were less sophisticated. The chess and backgammon games are loaded with intensive software programs that follow the basic rules of artificial intelligence. They also require 8-b microprocessors, as opposed to 4-b types that, to this day, predominate in hand-held electronic sports games. (One exception is Fidelity's Checker Challenger which also uses a 4-b processor.) In addition, much more memory, both volatile and nonvolatile, is used to store the rules of chess and backgammon and to keep track of each move. Hence, these electronic board games must demand a higher price than toys like electronic hockey and baseball or the more popular space invader games. The latter are primarily aimed at youngsters and test their dexterity. But strategy-oriented board and card games like computerized backgammon, chess, and bridge challenge the player's intelligence and ingenuity and appeal to a narrower segment of the game-playing public.

Down-sizing for a lower price

Tryom has successfully sold backgammon games that retail for more than $100. In its newest version, Omar V, the company has reduced the set to hand-held size and dropped the price below $40. Omar V uses a single-unit liquid crystal display for reading out the moves. Compared with the original Omar game, which had a full printed circuit board complete with 6800 microprocessor and a 6-kilobyte memory, this latest version holds all circuitry on one chip—Fairchild's 3870 microcomputer. The package consists of one 40-pin chip, an LCD display, a 25-key keypad, and a R-C oscillator for the clock. It is battery-operated.

Mr. O'Hara admits that it wasn't easy to pack this density on one chip. All software is written in assembly language, because no high-level language has yet attained the proper flexibility. The real challenge, according to Mr. O'Hara, was to write a concise algorithm that would fit all instructions in the available memory of a 3870. A polynomial had to be devised to assess each move as the game progresses. The polynomial is goal-oriented; hence the equation keeps changing with every move.

Mr. O'Hara defined the architecture for the backgammon game, wrote the polynomial, translated assembly instructions from a high-level language, and packaged the circuits — all in his San Diego one-room research shop. Hardware and software consultants are available to him for work like this, but for the most part, he alone constructs the prototype. The finished chip was delivered to Tryom's manufacturing plant and headquarters in

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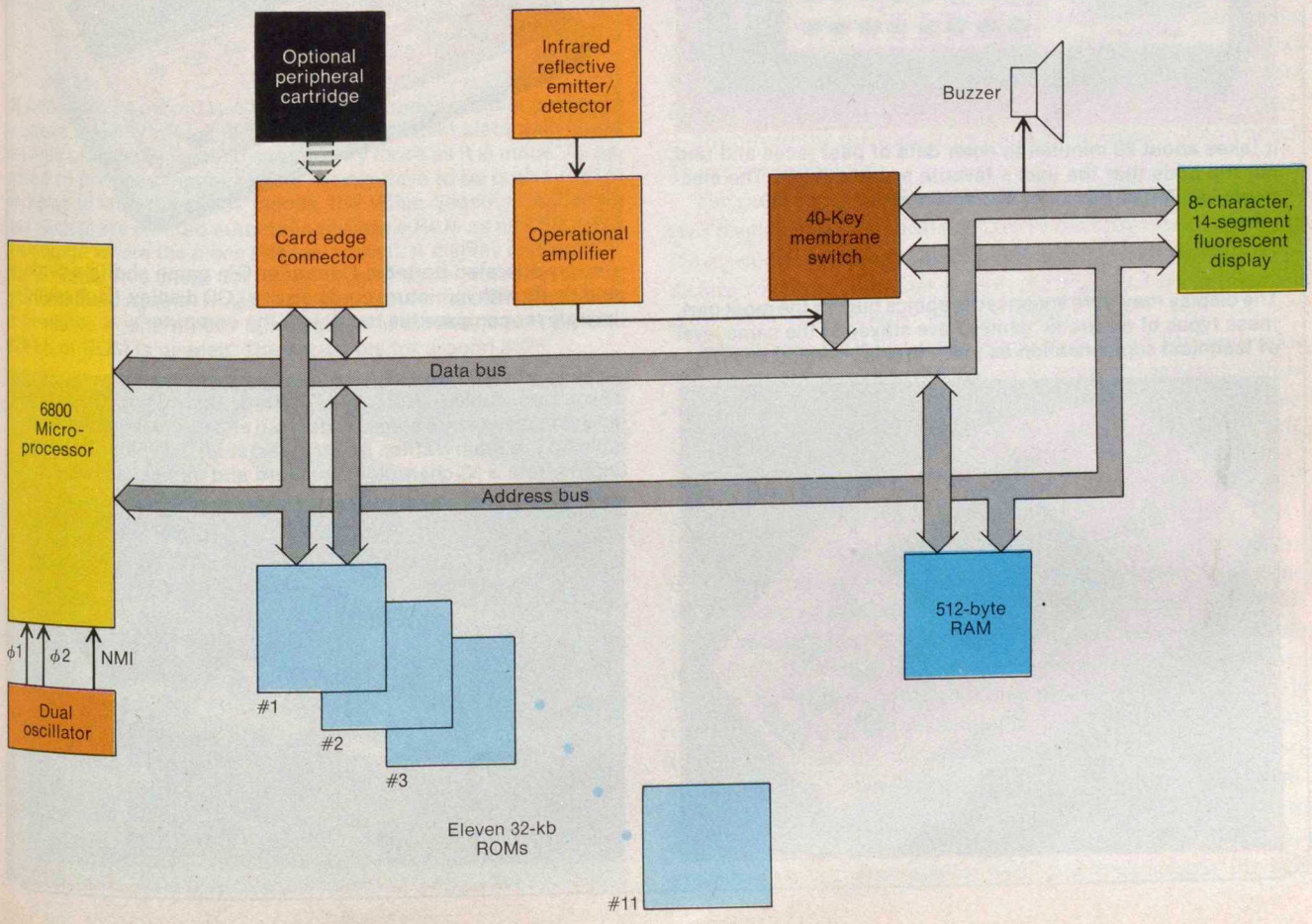
Beachwood, Ohio. And all with maximum packing density at minimum component cost.

This year, the company introduced also a number of chess games that run the gamut from a high-end three-module set to a lower-priced hand-held version. On the low end is the Electronic Chess Toy, which has five levels of play, from beginner to expert. It also features a problem-solving mode and retails for under $50. As with Fidelity's eight-level Sensory Chess Challenger, the player competes with the computer, which looks ahead at possible moves. The Fidelity game has the eighth level look ahead at five individual moves. This requires 32 kb of ROM to analyze as many as 3 024 000 possible positions.

Making computers think chess

Chess is a classic problem in artificial intelligence. Researchers have been striving since the 1950s to program computers to play chess. At such places as Bell Laboratories, Carnegie-Mellon University, the Massachusetts Institute of Technology, Northwestern University, and Stanford University, researchers have tried to simulate how human players think and anticipate future moves,

[1] Tryom's Charles Goren Bridgemaster (left) received official endorsement from Mr. Goren only after his suggested enhanced bridge game strategies were incorporated into the set. The game is powered by the AC line and draws about one amp during operation. The standard model comes equipped with Goren's Standard American style cartridge. Other programmable cartridges for different styles may be plugged into an edge-mounted connector inside the set (below). Players slide cards, whose edges are magnetically-coded, over the infrared reflective emitter/detector to read in their cards. Bids and consequent plays are keyed in through a 40-key membrane switch. Play-by-play storage is provided by a 4k RAM, while the algorithms for bridge are stored in 11 32 kb ROMs. The 6800 microprocessor controls the game and sends out vocal rejections through the buzzer for illegal bids and reneges. Using the 8-character fluorescent display allows one to three players to play against the computer or have the computer play against itself.



Electronic games– mostly old, something new

In 1977, when hand-held electronic games first made a strong showing on department store shelves, the circuitry they used was, for the most part, the TMS 1000 microcomputer built by Texas Instruments. Today, the TMS 1000 is still the workhorse of the electronic toy and game industry. The micros are custom-made for each toy manufacturer to perform a desired function. The functions have not changed much over the years. Electronic baseball and football are still played by the same simple rules. Electronic pinball games and sound-matching games such as Simon haven't really been enhanced. Even "educational" toys, such as TI's Speak and Spell, have much the same configuration they had when introduced. Speak and Spell made its debut at the June 1978 Consumer Electronics Show.

Two exceptions to this trend were offered this year by Mattel Electronics of Hawthorne, Calif. The first is the Brain Baffler, a product that lets players play eight different word and number games. The second is Horse Race Analyzer, which calculates odds on favorites from the records of past races. Both devices use 4-b microprocessors with limited memory. Both products give the player a few more challenges and rewards than he gets when keys are depressed to match sounds. Brain Baffler sells for $50, while the Horse Race Analyzer retails for $125.

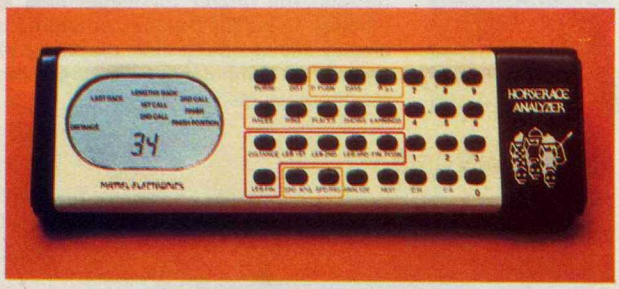
For youngsters, Fischer-Price has brought out a talking doll, Baby Soft Sounds. A speech synthesis chip and a controller chip allow the doll to speak 16 different sounds at random as the doll changes position. The synthesis chip was designed jointly by Fisher-Price and a Canadian company, Siltronix Inc., and fabricated on a custom production line at Precision Monolithics Inc. in Sunnyvale, Calif. The IC manufacturer makes chips that must pass the most rigorous military-acceptance tests. Now, it is planning to expand its custom fabrication service to cater to other toy and game manufacturers. Precision Monolithics says it guarantees customers the same high reliability in their chips for toys as the military contractors gets for chips that go into missiles.

As toys start to talk and listen more, more talent will be required to design the chips. Texas Instruments, National Semiconductor, General Instrument, Votrax, and a couple of Japanese companies are already offering speech-related ICs. But going the route that Fisher-Price took might be a more economical solution. All design and development was done by them and Siltronix. Even the mask for the wafer IC was delivered to Precision Monolithics. The IC maker then took the mask to fabricate the wafers and shipped the chips and placed them in the dolls. Fisher-Price says that's how it could ensure a high-quality product, yet expect to offer the doll at $34 to the consumer.

The speech synthesis IC uses a technique called formant synthesis. On the chip, formant frequencies are generated that correspond to the natural resonances of the vocal track created during human speech. A modulated signal is then passed through two levels of filtering, creating an analog of the corresponding resonance of the mouth cavity. The center frequencies shift with time, in accordance with the changing resonances of the voice. Coefficients for the filters are stored in a ROM.

The next phase to fill consumer demand for more electronics may entail some application of speech recognition. Who knows? Someday youngsters may have an army of electronic wooden soldiers march about the house at their commands.

—*N.M.*



It takes about 20 minutes to enter data of past races and find out the odds that the user's favorite horse will win. The electronic version of the *Daily Racing Form* sells for $125.

Battery-operated portable Computer Gin game shuffles cards and deals with miniature cards on the LCD display. Each round lets player compare his hand with the computer's.

The display may have enhanced graphics but, for the most part, these types of electronic games have stayed at the same level of technical sophistication as when first introduced in 1977.

Anagrams, Build-A-Word, Flash Word, Copy That, Go Hang, and Concussion are some of the word and number games available on the Brain Baffler. An 8-character LED displays both the inputs from a 38-character key board and games' answers.

based on present positions. Different strategies have evolved that may someday enable a computer chess game to beat a grandmaster.

There are three essential parts to any chess program: generating the move, searching, and evaluating the move. Generating the move is the easiest task, since programming the game's rules and the board's layout are fairly straightforward. More difficult are the search and evaluation. The computer must search for the best move to counteract the human's attack. Today, this search is done with use of a well-known technique from artificial intelligence work, called look-ahead tree-searching. The computer searches next move by branching out to other possible moves from an initial node. Each set of possible moves that a player can make is called a "ply;" thus, four plies would represent moves for each player. To evaluate the branching moves for each player out of, say, 50 moves, perhaps 35 would be considered legal—which means that the computer has to evaluate 35-to-the-50th-power positions to cover all possible conclusions. This turns out to be impractical with today's computer power. Hence, the computer is forced to evaluate a certain number of positions in a limited time. Several ways have been tried to get the computer to make a more efficient limited search, but the best search is still one that considers the most positions.

Dr. Hans Berliner of Carnegie-Mellon, once one of the country's top 10 chess players, strongly believes that the computer will beat humans someday. However, because chess is such a personal game, testing human foresight and intelligence, no grandmaster has thus far formally endorsed any of the computerized games.

The officers of Fidelity have entered the company's games in computer chess tournaments. In the First World Microcomputer Chess Championship held in London this past September and in a similar North American competition, Fidelity's games took first place over other microcomputer-based games. Fidelity's entries, however, were enhanced versions of games and are not presently available from retail stores.

Despite their success, microprocessor-based chess games have yet to be endorsed by a grandmaster. Such is not the case with backgammon, where Omar Sharif, the actor, who is both a bridge and backgammon expert, has given his personal endorsement to Tryom's backgammon games.

[2] Adding voice output to consumer electronics product is a key to success. Fidelity Inc. of Miami, Fla., in its latest electronic chess set, has provided a voice to speak every move as it is made. As opposed to previous models where moves have to be both keyed in and played with the chess pieces, the Voice Sensory Challenger has each move entered automatically into a RAM as an LED lights the square where the piece has last moved. A display is used for a chess clock. This chess set has 64 programmed games by leading grandmasters against which the player can try his skills. The audio is available in one of four languages. For all that, a phenomenal 224 kb of ROM is needed. The set retails for around $325.

Bridging intelligence with strategy

Another coup for Tryom was getting a leading bridge authority, Charles H. Goren, to endorse the company's newest entry in the electronic strategy game market. He "would not give us the right to his name until he was satisfied that the computerized version of bridge met all the challenges of a nonelectronic bridge game," Mr. O'Hara says. The computer specialist adds that Mr. Goren made several suggestions that were incorporated to make the game more interesting.

Tryom's game uses Goren's Standard American style of play and assumes any number of hands at either of two levels of skill. A multitude of rules are stored in 11 32-kb ROMs—the most memory used in any intelligent game (Fig. 1). Mr. O'Hara says that as soon as 64-kb ROMs become economically practicable they will be installed to upgrade the game.

One feature of the bridge game is that it can be expanded with cartridges that insert into the housing. Each cartridge is for different playing rules—European, American, etc. "There are 50 million card players, of which 15 million are devoted bridge enthusiasts," says Mr. O'Hara. "We intend to tap every single one of them."

In developing the Goren Bridgemaster GB2000, Tryom first got hold of the Ph.D. dissertation of a graduate student, Anthony Wasserman, at the University of San Francisco. For Tryom, Mr. Wasserman converted his dissertation program for artificial intelligence use from Algol to Fortran. The program was then rewritten in assembly language. It took three man-years to improve the algorithms to Goren's standard and convert the original 5100 instruction lines in Algol to 22 000 lines in assembly language. The whole project including software, hardware and tooling cost Tryom $250 000 between concept and finished product. To convert the software from Fortran into assembly cost about $1 per assembly line.

The game uses a moving eight-character alphanumeric fluorescent display and an optical detector to read the cards, which are binary-coded for their value. In addition, an audio feedback indicates when the computer accepts the plays and when there are errors. The Bridgemaster sells for $400.

Tryom won a Design and Engineering award for innovation for the Bridgemaster at the annual Consumer Electronics Show in Chicago this year. The company was awarded a similar distinction at the same show in 1977 when it introduced its electronic Gammonmaster backgammon game.

A constant upgrading effort

The engineering goal for all games is to consolidate the circuits on as few chips as possible. Tryom's top-of-the-line chess game will use the single-chip 3872 microcomputer, with a 4 × 8-kb ROM and a 128 by 8-b RAM, when that IC becomes available next year. Tryom's top chess game today is its Champion Super System III, which consists of three modules. Its intelligence is divided between two of the modules. The master unit contains all the electronics to let one play at an infinite number of levels—that is, the player selects the level by setting the time for the computer to respond with its moves, anywhere from zero seconds to 100 hours. The game has all the international chess rules programmed in, can play against itself and even suggest the best

Competition from video strategy games

The biggest competition to hand-held strategy games comes from video games designed for personal computers. The plug-in games are programmable and controlled by a microprocessor. Initially, the video games' main attraction was that a user could play a game like interactive hockey on the home video screen. That is still the case today.

In the last couple of years, there has been an increase in vivid sound and visual simulation in video games. This has come about through the availability of plug-in ROM cassettes, too numerous to mention. Video games now play very respectable chess and backgammon. In fact, they have been known to defeat hand-held stragegy games. Units from Atari, Magnavox, and Mattel represent the bulk of today's video games.

One of the more popular games, that was initially a Japanese game, "Space Invaders," lets the player shoot down invading spaceships on the computer display for points. Atari, which is based in Sunnyvale, Calif., has introduced four new home video games this year: Maze Craze, Video Checkers, Dodge'Em, and Championship Soccer. The soccer game was designed by a professional soccer coach, and it features a scrolling playing field. This feature gives the players the impression that they are above the playing field, following the plays as the action moves up and down the field.

A smaller company, Activision of Sunnyvale, has offered four cartridges that can only be plugged into an Atari video computer system. Activision is being sued, however, by Atari, for allegedly stealing trade secrets. Activision's owners worked for Atari before they left to form their own company.

Mattel Inc. of Hawthorne, Calif. has 17 video cartridges that can be plugged into its recently introduced Intellivision system. This system consists of a master component that can be connected to any standard color TV receiver for displaying the games. The master component is controlled by a 16-bit microprocessor and has two unique game controllers. A controller for each player has 12 touch-sensitive keys, four play-action controls on the side, and a control disk that can move the game's pieces on the screen into one of 16 different directions.

Another outfit, Automated Simulations Inc. of Mountain View, Calif., is offering seven games, of which two are classified as science fiction and five as role-playing. The science fiction games are more sophisticated descendants of the long favorite arcade game of "Star Trek." The player is placed deep in space as a commander of a fleet of starships and is asked to shoot down enemy starships while avoiding getting hit by them. The role-playing games are electronic cousins of the popular Dungeons and Dragons participation board game. Players assume roles of medieval persons who go on quests to explore vast labyrinths of dungeons, find treasures, and exterminate all the dragons.

John Freeman and Jim Connelley, who are part-owners of Automated Simulations, wrote their programs for Dungeons and Dragons in Basic on a Commodore PET personal computer. They then converted the programs so that they could be used on both Apple and TRS-80 computers. They also plan to have cassettes available for the new Atari 400/800 personal computer. The games are also available on diskettes. Typical prices for such video games range from $15 to $35 in both cassettes and diskettes. —*N.M.*

Sales of electronic games and toys is expected to increase at 25 percent annually. The total video market for 1980 is forecast at $400 million. A large part of this market consists of programmable plug-in video cartridges of which Atari Co. of Sunnyvale, Calif., is the largest supplier. Some of their products are shown.

move for a player. An accompanying chessboard does not use regular chess pieces; instead, it displays the game on an LCD. The custom-built display shows a full 64-square chessboard with the pieces in a 3-inch square area.

An electronic printer can be attached to the set for a record of any moves and to show the full chessboard position anytime during the game. Fidelity will also be providing a printout for its top chess game in 1981.

An additional Super System accessory will store the positions of different games for up to one year. The memory will reassess the player's strategy by providing moves for up to 10 plays.

Fidelity's Voice Sensory Challenger has eliminated the from-to display of chess moves (Fig. 2). Instead, each position is written into a RAM, which automatically lights a red LED on the square receiving the chess piece. Players no longer need key in their moves. Sensors on the board detect the changes, and the computer announces them in its voice mode. The moves can be spoken in one of four languages: English, German, French, and Spanish. This set features a ninth skill level and stores 64 preprogrammed champion games, which can be used as a teaching tool by allowing the player to second-guess the moves that a grandmaster has made. All these features need a large memory, and the Voice Sensory Challenger has 224 kb of ROM.

The quartz clock for the computer is also used as a chess clock on an LED readout.

In bridge games, Fidelity has introduced a voice version for all plays and bids. The game, however, is limited in that it cannot be expanded for other rules and challenges, as Tryom's can with its cartridges. Tryom is planning to introduce voice communication in its bridge game "sometime next year," Mr. O'Hara said.

Other miniaturized versions of chess and backgammon are emerging from companies other than Fidelity. Radio Shack, for example, in its Fall catalog, lists an 8 × 5-inch Tandy Chess Traveler set that sells for just under $100. The set was designed for Radio Shack by Tryom.

After computerized chess and bridge, what next? Well, there's always Othello, the game played in ancient Egypt. Because a move may place the player in a completely opposite strategic position from the previous move, a self-contained computerized version will be "a tough nut to crack," Mr. O'Hara admits. But then researchers in artificial intelligence wouldn't have it any other way—they feed on nuts to be cracked. In fact, Fidelity programmers are already hard at work on a hand-held computerized Othello game. ◆

Mokhoff—Beating an electronic opponent is a challenge