DECEMBER 1973
THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

spectrum

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the cover
Components used in consumer electronics products were the ingredients for Art Director Herb Taylor's jolly St. Nick.

Special report

What's new in consumer electronics circuits

From arcade amusements to auto seat belts, solid state satisfies customer fancy and Government mandate alike

You're on the eighteenth in two. A birdie and you've got the tournament. A pressure putt!

You read the break, but you could use an assuring comment. Sweat on your brow, you wait for that friendly voice. But you've forgotten! They didn't design your robot caddie to offer advice!

Holiday shoppers seeking new gadgets and novel gift ideas won't be disappointed by the electronics industry this season. The weekend duffer can purchase an electronic caddie that homes in on a device carried by its "master" and follows him everywhere (Hewson and Associates, Indio, Calif.). The well-heeled family can order an electronic range that cooks by computer. The amateur photographer can graduate to an electronic camera capable of immediately ejecting and developing its own prints (see pp. 76–83). Battery powered calculators are now within the reach of almost everyone. And even in the 1974 family automobile, the consumer is face to face with performance and safety features provided by solid-state technology and innovation.

While the product applications are plentiful, so too are the forces that brought them to market. Ranging from legislative fiat to skillful deployment of the advertising dollar in order to *create* a demand, cases abound of electronics gaining ever more ground in the consumer market. But heady optimism has been checked by the worldwide energy shortage.

Beyond the buzzer

It was legislation that brought electronics to Detroit, this year. Consumers in the market for a 1974 model auto are finding that the electronic watchdogs on board have become more aggressive in their pursuit of safety per Motor Vehicle Safety Standard MVSS-208. Seats and seat belts are now wired into an interlock system that prevents a car from starting unless the driver (and any right-hand front passenger) has "buckled up." Compliance with the safety standards prompted the design of special integrated-circuit logic. Delco Electronics' Ronald W. Vahle described one system—the seat belt interlock developed for General Motors (Fig. 1)—during the 1973 WESCON Professional Program on Circuits for Consumer Electronics.

The Delco system does not directly interfere with the ignition, but accomplishes its mission by actuation of a normally closed starter interrupt relay (Fig. 2). The bipolar logic chip opens this relay if the seat sensor and belt sensor are actuated in an improper sequence. But built-in time delays prevent shutdown due to rough roads and bouncing passengers.

The complete system consists of seat switches, belt switches, electronic module, connecting cables, starter-interrupt relay, warning lamp, and buzzer. A bypass switch under the hood allows starting in case of a system failure.

The center passenger hookup is similar to that now in use in all 1973 vehicles. It contains a normally open seat switch and a normally closed belt switch. A lamp and buzzer are actuated if the seat is occupied without the belt being fastened. There is no requirement for sequential operation and no interlock with the starter.

Conversely, both the driver and right-hand passenger positions use normally open seat belt switches. The resistor and capacitor on each belt input provide filtering for electrostatic charge.

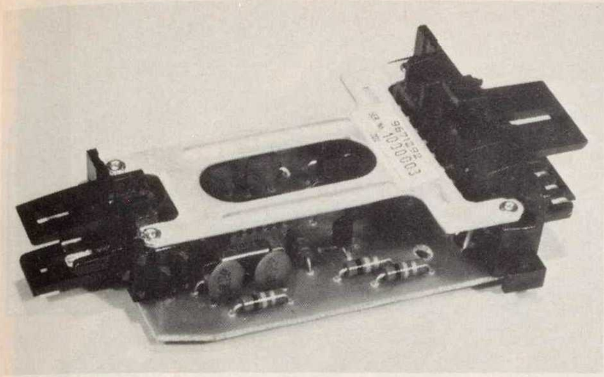
The interrupt relay output (pin 13) and warning output (pin 12) are normally at ground potential through a transistor switch in the IC chip. If all occupied seats have the belt switch closed after the seat switch is closed, pins 12 and 13 remain at ground potential. If, however, a belt switch is closed prior to the closure of a seat switch, a signal is transmitted to the transistor switch on pins 12 and 13. This causes these outputs to go high and turn on Darlington D_1 and D_2. They, in turn, actuate the starter interrupt relay, preventing cranking, and turn on the buzzer and lamp.

The same result occurs if the passenger occupies his seat, closing the seat switch, and cranking is attempted with the belt switch open. If neither belt switch nor seat switch is closed, the starter can be actuated by reaching into the car without sitting (mechanic start feature) for serviceability.

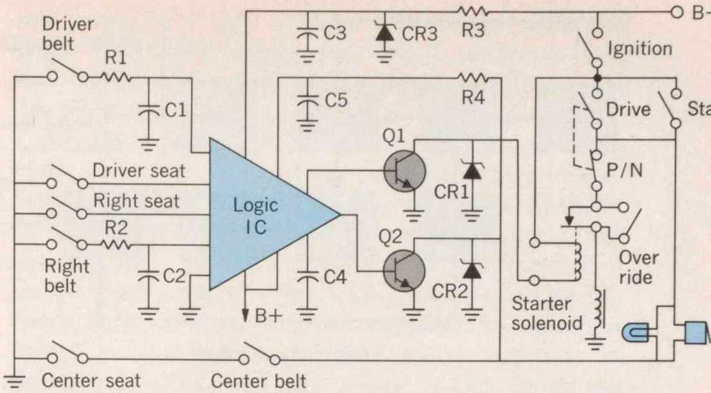
Another convenience feature is the "good-start" latch actuated by a voltage on pin 14, with R_4 and C_5 providing filtering for noise and unwanted signals. This latch prevents Darlington D_1 from turning on once a good start has been obtained. The car can then always be restarted, regardless of the condition of the passenger position belts or seat switches, as long as the driver remains seated.

Bounce protection is derived from a time delay at pin 11 obtained by charging capacitor C_4. When the seat inputs are opened, pins 13 and 14 are not driven high until sufficient voltage appears on pin 11 to activate a differential switch. Thus, a car on rough roads with bouncing occupants will not trigger the warning system. Provided seat belts remain fastened, bounce

Don Mennie Associate Editor

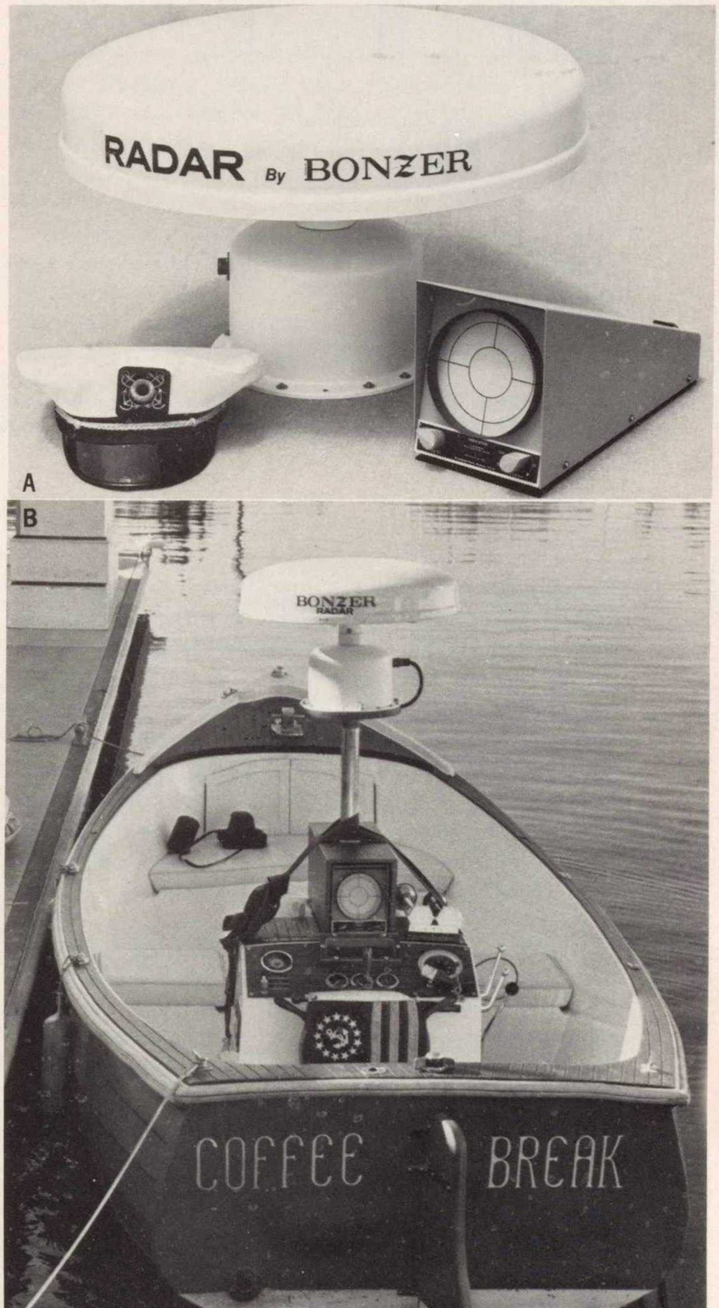


[1] **The seat belt interlock for General Motors cars is contained on a single printed circuit card mounted under the right front passenger seat.**



[2] **Starter interrupt relay (above solenoid) prevents cranking if the logic circuits sense an improper seating/buckling sequence while the buzzer and lamp provide warning.**

[3] **Compact boat-radar antenna and display electronics from Bonzer (A) can mount easily on almost anything that floats (B). Argonauts take note.**



protection prevents annoyance from the buzzer and lamp while a car is in motion.

In addition, a nonsequential warning sequence is designed into the logic chip. After a good start has been obtained, this forestalls a warning when the passenger seat switch is opened longer than the allowed bounce time, as may happen with squirming children who might inadvertently set up a bad sequence.

Radar afloat

Consumer electronics for vehicle safety is not limited to automotive markets exclusively, and neither is legislation the sole spark plug for corporate attempts to match solid state to consumer need. Owners of small boats now have the option of a compact, lightweight radar available at relatively moderate cost (Fig. 3).

Introduced as model SR-20 in June 1973 by Bonzer,

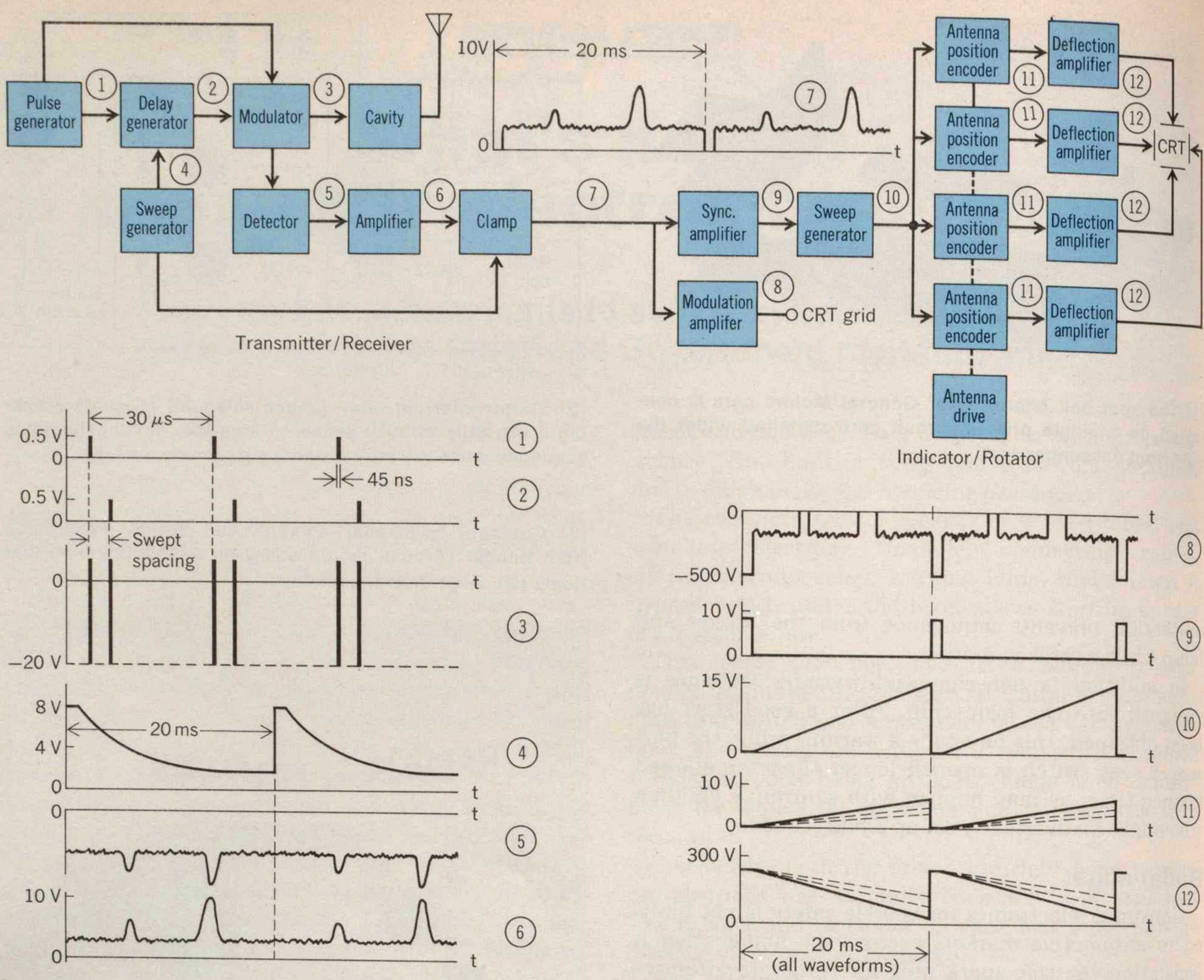
Interlocks: required but resented

While seatbelt interlocks are universally required on all 1974 cars, they are far from universally popular. An editorial in the October 1973 issue of *Fortune* gives one highly critical view of interlocks and labels them "... a misguided approach to auto safety, a result of technocratic tunnel vision ...".

Predictably, the *Fortune* viewpoint is concerned with the interlocks's potential for bad PR—another wellspring of ill will against big business and big government. Widespread consumer dissatisfaction at being forced to use belts is predicted with claims that "millions will be paid to mechanics to bypass the system and for repairing breakdowns of the complex apparatus." Despite moonwalks and pocket calculators, could faith in the integrated circuit have failed to catch on with Detroit's upper management?

Seatbelt and interlocks were mandated for one reason only: they give an automobile's occupants a much improved chance to survive collisions. They deserve to be evaluated on their ability to meet this important challenge.

Training programs, crackdowns against drunk drivers, tougher inspections, engine tune-ups, or kind thoughts about capitalism count for nothing in the physical reality of a serious accident.—*D.M.*



[4] Waveform mapping of the boat radar circuit illustrates the dual-pulse technique for determining distance. Detected objects are first evidenced as negative pulses at the detector output (5).

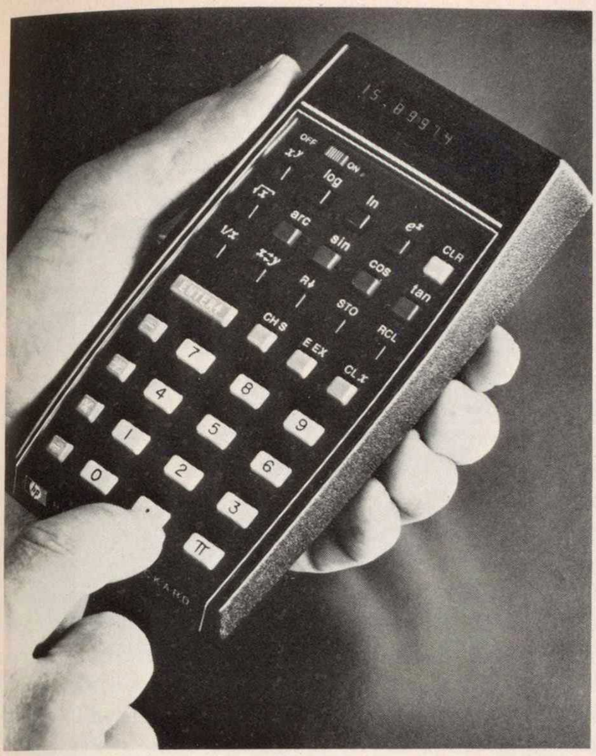
Inc., the new boat radar is more a result of market economics than designer foresight. A direct descendant from an established line of electronic altimeters for private aircraft, the Bonzer device is considerably different from most conventional radar sets. In fact, it began as a collision avoidance system for small aircraft in the late 1960s. But Bud Wiley, Bonzer's president and chief engineer, recalls that the private plane business "went to hell in a hand basket" during 1970–1972, and the demand for optional on-board safety devices disappeared. So Bonzer turned its know-how toward the boating enthusiast.

The electronics employed by Bonzer offer a small, light-weight radar listing at $1495 with introductory discounts available. The radar is limited to a 10–2500-yard range because it must operate from a clean, but power-limited RF source, such as a vacuum tube or transistor oscillator, free of FM or other noise. Gunn diodes and frequency multiplication techniques are not suitable.

The radar transmits and receives continuously through one antenna at 3 GHz, and dc power consumption is 2.5 amperes at 12 Vdc. Basic operation depends on generating a train of dual pulses (Fig. 4). The time interval between the first and second pulses in each pair is continuously variable and linearly swept. At some point in this sweep, reception of a first pulse reflection (from any object within range) will coincide very closely with initiation of a second pulse. Such reception of a first pulse reflection "primes" the microwave oscillator's resonant cavity and causes a small shift in the startup time it would otherwise exhibit in producing a second pulse. This shift is detected, amplified, and fed to an electrostatic display tube where objects appear as intensified spots.

Because the time between pulses in each transmitted pair is a varying but predetermined interval, the distance to detected objects is directly determined by the unique interaction between a first pulse reflection and second pulse generation. A single complete pulse train sweep takes 20 ms, and sufficient space is allowed between adjacent pulse pairs to eliminate the possibility of interference.

Bonzer also claims the law of averages is on its side when it comes to interference between two or more of the radars operating in the same marina. The intervals when pulse reception can be interpreted as an object are very short; therefore, most stray incoming pulses are automatically ignored. The few remaining strays can trigger an occasional flicker on the radar screen, but not a continuous blip.



[5] **Drawing 500 mA from rechargeable batteries, the Hewlett-Packard HP-35 operates four hours before resting.**

Handy handful

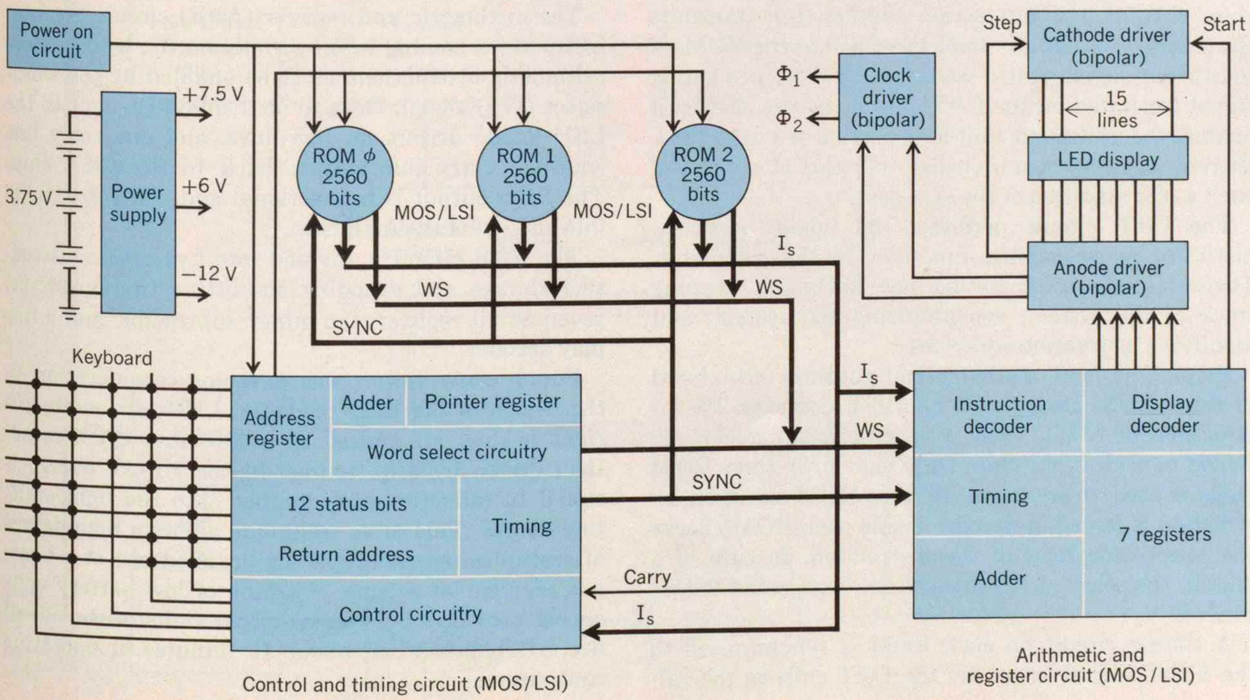
Hand held and battery powered, the compact portable calculator is one of the hottest consumer products introduced in recent years. Volume production has brought the cost well below $100 for many of the "four function" models which handle only addition, subtraction, multiplication, and division. Discounting among the more powerful (and expensive) types includes Hewlett-Packard's HP-35 calculator (Fig. 5), now available at $295, a $100 drop from the initial $395 price, and Texas Instruments' SR-10 electronic slide rule, introduced at $149.95 in November 1972 and now retailing at $99.95.

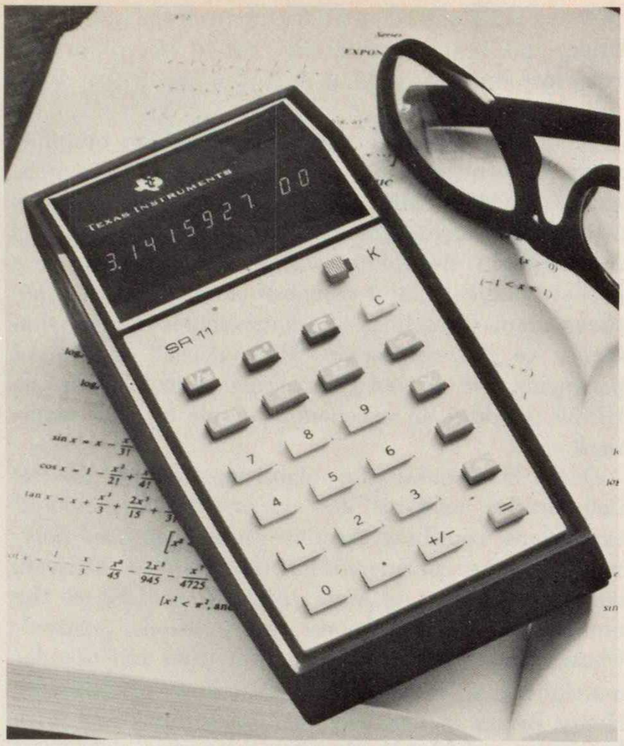
While the housewife and shopkeeper can probably make do with the basics a four function unit provides, anyone involved with complex scientific or financial calculations needs expanded capability. Compressing the required capability within the confines of a pocket-sized calculator demands close cooperation between many disciplines—from specialists in algorithm theory to the subjective "shirt sleeve" aspects of packaging and human engineering. A look inside the HP-35 provides an excellent example of such teamwork.

David S. Cochran, top algorithm designer for HP Laboratories, explains that power series, polynomial expansions, continued fractions, and Chebyshev polynomials were considered for the HP-35's transcendental functions. All were too slow because of the number of multiplications and divisions required. Chosen was an iterative pseudo-division and pseudo-multiplication method first described in 1624 by Henry Briggs in *Arithmetica Logarithmica* and later by Volder and Megitt. By using a bit-serial data word structure, circuit economies could be achieved without exceeding a one-second computation time for any function.

HP designers Thomas M. Whitney, France Rode, and Chung C. Tung report on the HP-35's electronic subsystems consisting of five metal-oxide-semiconductor/large-scale-integration (MOS/LSI) circuits: three read-only-memories (ROMs), an arithmetic and register circuit, and a control and timing (C&T) circuit. Three custom bipolar circuits are also part of

[6] **A combination of MOS and bipolar circuits organized on a digit-serial, bit-serial basis allows a minimum of interconnection within the HP-35 layout.**





Texas Instruments' latest portable scientific calculator, the SR-11, conserves battery power by automatically interrupting the LED display 15 seconds after the answer appears. It also features a "constant" switch for repetitive multiplication or division by a constant. Introduced at $119.95.

Famous for the Bowmar Brain®, marketed through saturation TV ads around income tax time last year, Bowmar has moved into the scientific hand-held calculator field with the MX100. It handles exponents, trigonometric, and log functions, and includes memory. Retail price is $179.95

the package; a two-phase clock driver, an LED anode driver/clock generator, and an LED cathode driver (Fig. 6).

Three main bus lines connect the MOS circuits. One carries a word synchronization signal (SYNC) generated by a 56-state counter on the control and timing (C&T) chip. On another bus, instructions (I_S) are transmitted serially from the ROMs to the control and timing chip or to the arithmetic and register chip. A third bus, instruction address (I_A), transmits the instruction address from the C&T to the ROM. A fourth bus signal, called word select (WS), is a gating signal generated on the C&T chip or by the ROMs; it enables the arithmetic unit for a portion of a word time, thereby allowing operations on only part of a number, such as the mantissa or the exponent.

The C&T circuit performs the major nonarithmetic, or housekeeping, functions in the calculator. These include interrogating the keyboard, keeping track of the system, synchronizing the system, and modifying instruction addresses.

Preprogrammed mathematical routines are stored in three ROM chips, each of which contains 256 instructions of 10 bits each. A specific select code is assigned to each ROM chip. Only one of the three ROM chips is used at any time. When a ROM selection instruction is issued, a decoder inside each ROM checks the select-code field of the instruction. In case of a match, the selected ROM turns on. Unselected ROMs turn off.

A timing circuit on each ROM is synchronized to the SYNC signal issued by the C&T chip as the calculator is turned on. This circuit then keeps the ROM chip running synchronously with the rest of the system.

A ROM address register on each ROM chip receives the address sent out by the C&T chip. The corresponding instruction is placed on the instructions (I_s) line, provided the ROM chip is turned on. The ROM chip also issues word-select signals for certain classes of instructions.

The arithmetic and register (A&R) circuit executes instructions coming in bit-serially on the I_s line. Most arithmetic instructions must be enabled by the word-select (WS) signal. Data to be displayed is sent to the LED anode drivers on five lines, and one carry line transfers carry information back to the C&T chip. The BCD output is bidirectional and can carry digits into and out of the A&R chip.

The A&R circuit is divided into five areas: instruction storage and decoding circuits, a timing circuit, seven 56-bit registers, an adder–subtractor, and a display decoder.

Power conservation was a major consideration in the design of the LED readouts. LEDs are more efficient if they are pulsed at a low duty cycle rather than driven by a dc source. In the HP-35, energy is stored in inductors and dumped into the light-emitting diodes. This drive technique allows a high degree of multiplexing; the digits are scanned one at a time, one segment at a time. Warning of low battery voltage is provided by special circuits that turn on all decimal points when about 15 minutes of operating time remains.

Examining the HP-35 from a human-engineering standpoint, Edward T. Liljenwall, industrial designer for HP, recalls that the keyboard was the most critical area of the design. The problem was to place thirty-five keys in an area approximately 2½ inches by 4½ inches and retain the ability to operate the keys without striking more than one at a time. The industry standard of ¾-inch center-to-center key spacing could not be maintained. A successful compromise was to use 11/16-inch center-to-center spacing for the numeric keys, and ½-inch spacing for all others while reducing the size of each key.

The keyboard had to be reliable, inexpensive, and low-profile, and have a good "feel." The design is based on the "oilcan" or "cricket" principle—that is, curved metal restrained at the edges can have two stable states. At each key location, the metal is raised to form a hump over a printed-circuit trace running underneath. Depressing a key snaps the metal down to make contact with the trace. The keys have a definite "fall-away" or "over-center" feel so that there is no question when electrical contact is complete.

The keys are divided into groups according to functions. The groups are separated by size, value contrast, color, and placement of nomenclature. The numeric keys, which are most frequently used, are larger and have the strongest value contrast.

The external package was developed with aesthetic appeal of major importance. The sculptural wedge shape permits the calculator to be comfortably held in the palm of one hand or allows it to slide in a pocket easily. The keyboard and display slope upwards for a better viewing angle in desk-top use. Tapered sides visually break up the total mass of the package.

Since the introduction of the HP-35, Hewlett-Packard has marketed two more calculators, the HP-80 for business and financial problems and the HP-45, an advanced scientific version of the original HP-35.

Though sharing the technology of its science-minded companions, the HP-80 is conceptually unique. While the HP-35 solves functions (log, sin, cos, x^y) with a single keystroke, the HP-80 solves complex iterative equations with a single keystroke (once the appropriate data has been entered). Many of the important relationships used in banking, finance, and real estate have been programmed into the HP-80, obviating manual execution of subroutines.

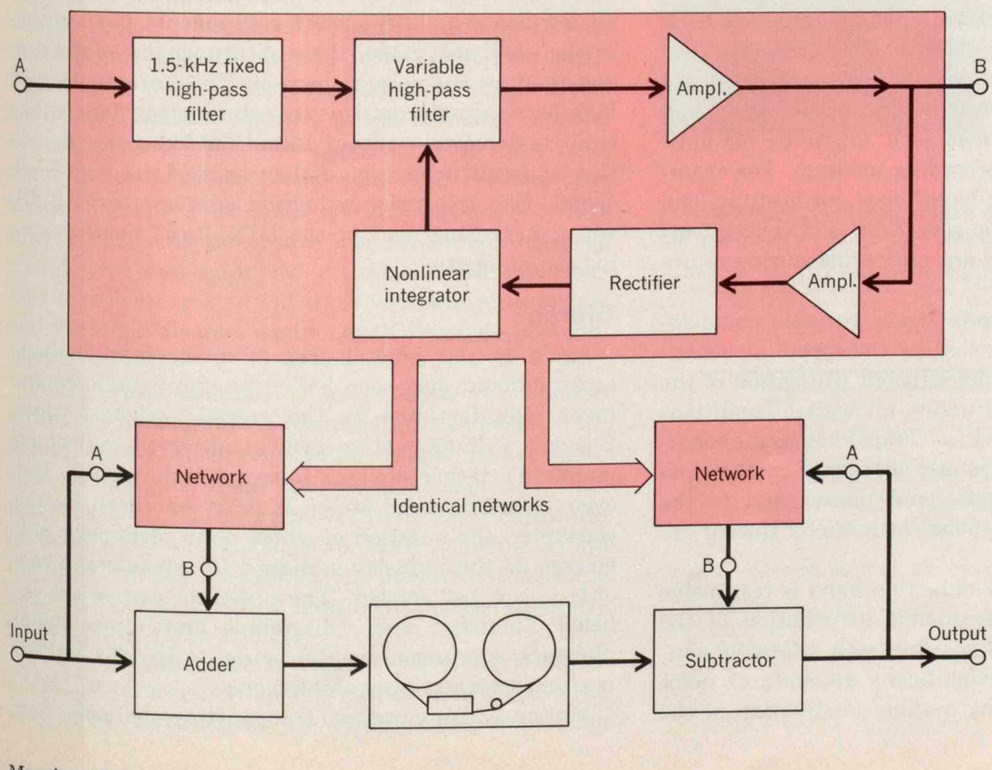
Putting the hush on hiss

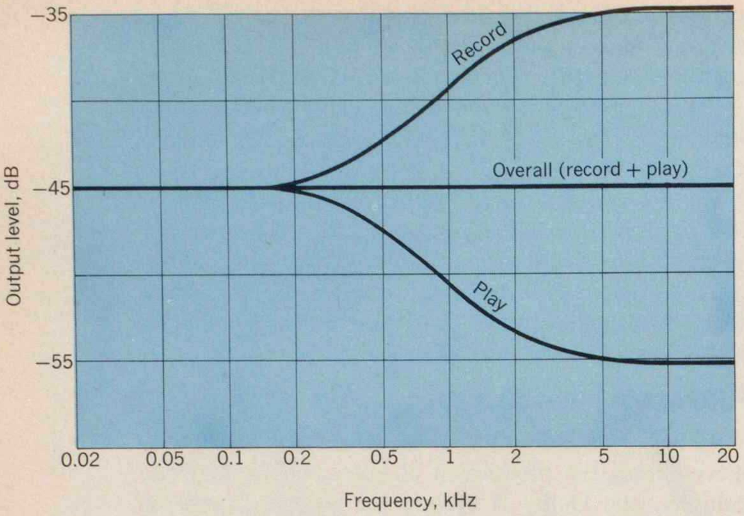
At home in Hollywood or on Broadway and far removed from the production of autos, boats, and calculators, the Dolby A system for reducing noise on master tapes has been employed by professional recording studios for several years. Recently, a modified version, the Dolby B system, has made a significant impact on the consumer market for prerecorded cassette music tapes. Dolby B circuits are now built into many of the better-grade cassette players, and outboard Dolby units are available for upgrading older equipment. Ampex and Columbia, two of the largest producers of prerecorded cassette tapes, have switched completely to the Dolby B system. And other companies have taken a similar course.

For the consumer, the Dolby system has married convenience with performance. Cassettes began as a simple, low-cost, portable tape medium. With threading tape and juggling empty reels eliminated, even the most clumsy operator could make or play recordings easily.

But early cassettes proved unsatisfactory for all but the least discriminating music lover. The narrow

[7] **The Dolby noise reduction system uses variable equalization networks in the record and playback circuits to achieve improved signal-to-noise ratio.**





[8] Dolby B record and play processors have complementary low-level frequency response characteristics.

(⅛-inch) tapes, driven at low speed to increase playing time, suffered from dropouts, poor signal-to-noise ratio (hiss), and lack of high-frequency response. Added to these shortcomings was a heavy dose of wow and flutter from cheap tape transports. Although improved workmanship could eliminate many of these problems, there was little cause to invest the effort since the all-important signal-to-noise ratio stubbornly resisted improvement via conventional means. Introduction of the Dolby B noise reduction system changed this assessment dramatically.

As explained by system developer Ray Dolby in a paper published by the Audio Engineering Society, Inc., the Dolby B system can actually be classified as a variable equalization scheme which surpasses the capability of fixed equalization methods long used to improve signal-to-noise ratio in both tape recordings and phonograph records (high frequencies are preemphasized during recording and deemphasized during playback). Fixed equalization characteristics must be chosen such that even high-level, high-frequency signals do not produce distortion when recorded. Therefore, the allowable high-frequency boost with fixed equalization is not as great as it might be for optimum utilization of the recording medium. For example, recording a piano or violin does not usefully load tape over the whole audio spectrum, and consequently, high-frequency noises are noticeable during reproduction.

The Dolby B system provides a variable equalization characteristic, controlled by the incoming signal, that achieves a much more efficient utilization of the tape recording medium under all signal conditions (Fig. 7). During playback a complementary characteristic is applied that restores all signal components to their correct amplitudes and phases and in the process attenuates any noise introduced during recording.

The width of the noise reduction band is responsive to the amplitude and frequency distribution of the signal. In this way, it is possible with relatively simple circuitry to obtain significant amounts of noise reduction without causing audible modulation of the noise by the signal. The Dolby B system employs such a method and is effective from approximately 1 kHz upwards; the noise reduction provided is 3 dB at 500 Hz, 6 dB at 1 kHz, and 10 dB at 4 kHz and above. Since the high-level signals are treated separately from the low-level ones, there are no high-level signal handling problems—only the low-level signals undergo any kind of variable action.

On the playback side of the Dolby B system, a network is provided which passes only low-level, high-frequency signals. These signals are allowed to return to the subtractor and partially cancel low-level noise components coming from the tape. High-level signals are now allowed to pass through the network, do not cancel, and remain essentially unchanged.

In partially cancelling the low-level tape noise, the playback half of the system also partially cancels any legitimate low-level components of the signal itself. But the record half of the system precompensates for low-level signal cancellation which takes place during playback (Fig. 8). When a network having identifical characteristics to that used in playback is used on the record side, the system output signal will be identical to that at the system input. For maintaining signal integrity, it is almost immaterial what networks are used, provided only that both are identical. But from a noise reduction point of view, the characteristics of the networks are crucial. If the frequency response or signal-limiting properties of the networks are incorrect, there may be insufficient noise reduction or, even worse, an apparently changing amount of noise reduction, depending on signal level.

Included in each network is a variable high-pass filter that automatically conforms itself to the amplitude and frequency distribution of the incoming signal. This technique yields sufficient noise reduction even under high-level conditions to avoid noise modulation effects (breathing). Under given signal conditions, the cutoff frequency is caused to shift upwards sufficiently to attenuate any high-level signal components, but not so far that low-level signals at higher frequencies cannot pass through. It is important that all low-level, high-frequency components pass, since, in the playback mode, these return to the subtractor and produce the noise reduction. Thus, attenuation of high-level signal components, eliminating tape overload, is achieved without impairing the noise reduction at frequencies higher than that of the high-level signal. Effective noise reduction on cassettes is 9 dB when measuring against the DIN 45405 noise-weighing characteristic.

Stereo[2]

Again in the general area of music reproduction, quadraphonics has been hailed by many audio equipment manufacturers as the greatest advance since Edison's cylinder. More cynical observers reflect on mankind's rather obvious binaural endowments. But even assuming quad stereo is fully embraced by the consumer, the question of which quad technology will emerge as the industry standard for phonograph records is not yet settled. The opposing camps are labeled "matrix" and "discrete," and four-channel playback equipment is often wired to handle both as insurance against early obsolescence.

Matrix systems use two transmitting channels, four speakers, and some sleight-of-hand with phase shift to achieve a "surround sound" four-channel effect. Compatibility with existing stereo and mono is questionable due to phase cancellation when channels are combined, and the scheme suffers from limited channel separation and crosstalk. But matrix proponents claim reduced separation is not important in the psychoacoustics of human hearing (see *Spectrum*, July 1972, pp. 55–62).

Claiming "true" four-channel sound is the Quadradisc, now manufactured by such major labels as RCA, Warner Brothers, Elektra, Atlantic, Reprise, Atco, and Nonesuch. As explained by Jerry Torczyner, project manager for Quadracast Systems, Inc., it carries the sum of the right and left front and back signals as the normal "45°-45°" groove wall, plus two superimposed high-frequency FM carrier signals which are never directly audible (Fig. 9). When played on a normal stereo phonograph, the Quadradisc delivers left front and left rear signals (CH1 + CH2) to the left stereo speaker and right front and right rear signals (CH3 + CH4) to the right stereo speaker. But most important, especially to broadcasters, is the Quadradisc's excellent monophonic compatibility because the entire AM and 60 percent of the present FM audience listen on single channel receivers.

With playback equipment adapted to the Quadracast discrete four-channel CD-4 system, the FM carrier information (CH1-CH2) and (CH3-CH4), is combined with the audible stereo signals in a special integrated circuit demodulator (QSI-5022) according to the algebraic relationship:

$$\tfrac{1}{2}(CH1 + CH2) + (CH1 - CH2) = CH1$$
$$\tfrac{1}{2}(CH1 + CH2) - (CH1 - CH2) = CH2$$
$$\tfrac{1}{2}(CH3 + CH4) + (CH3 - CH4) = CH3$$
$$\tfrac{1}{2}(CH3 + CH4) - (CH3 - CH4) = CH4$$

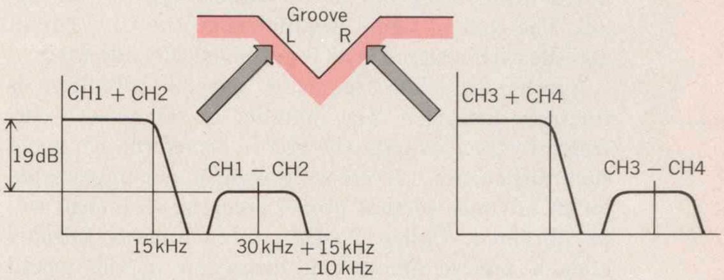
The four original audio signals come out equal in quality, independent, and each identically related to the direct signal and the carrier signal.

Despite the high frequency of the FM carriers (each at a center frequency of 30 kHz), damage to the Quadradisc groove from standard stereo cartridges, even at 5.5 grams pressure, is said to be slight, and satisfactory four-channel reproduction is maintained due to the hard limiting features of the QSI-5022. Special cartridges have been developed, however, and optimum performance is claimed for the Shibata-type stylus (Fig. 10). This stylus features increased surface area contact with the groove wall resulting in reduced record wear and improved pickup of modulated signals (carriers), and it will work well with any of several available discrete component CD-4 type demodulators.

Packing four channels of information into a single record groove employs a combination of special techniques during mastering. Most unique is low-speed cutting, originally done at $^{10}/_{27}$ of normal $33^1/_3$-rpm playback. This shifts the 30-Hz to 45-kHz bandwidth needed for CD-4 to 11 HZ to 16.6 kHz, which is within the disc cutting capability of available mastering equipment (Fig. 11). The latest cutters operate at $^1/_2$ speed from 15 Hz to 22.5 kHz.

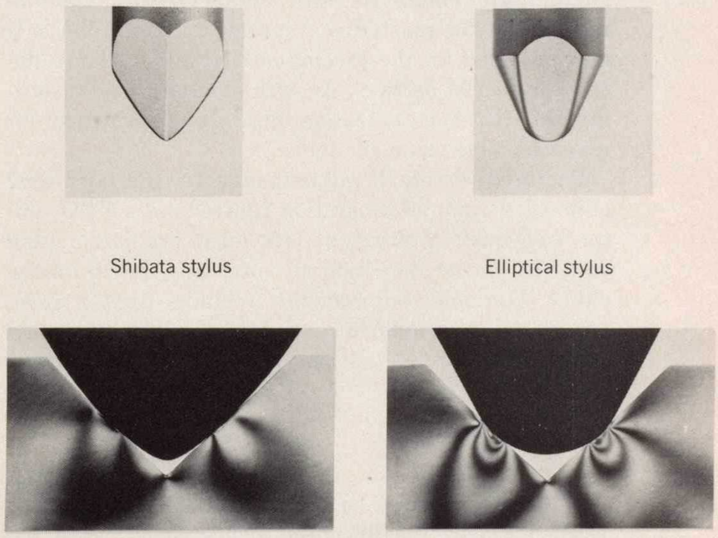
Since the difference of signals (CH1-CH2), (CH3-CH4) are recorded on an FM carrier from 20–45 kHz, very short wavelengths are encountered. Protection against unwanted noise buildup is provided by an automatic noise compression/expansion system consisting of a compressor in the cutting system (record) and an expander in the demodulator (playback). The amount of compression depends on signal frequency, nominally 10 dB for the midrange and 15 dB for the highs.

Since the direct signal and the carrier signal are recorded in superposition, modulated carrier reproduc-

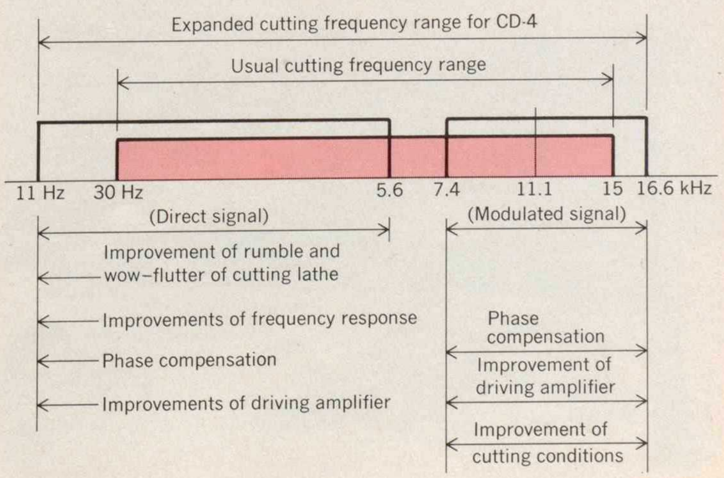


[9] The CD-4 quadraphonic phonograph record contains both audio and FM carrier signals on each groove wall. Pioneering work was done by the Victor Company of Japan Ltd. (U.S. subsidiary—JVC America, Inc.)

[10] Special Shibata-type stylus for CD-4 records reduces wear and improves FM carrier pickup by increasing groove wall/needle contact area. Note strain comparison.



[11] Reduced mastering speed allows a CD-4 record to be cut using only 11 Hz to 16.6 kHz of bandwidth.



tion is affected by the direct signal during playback. If the level of the direct signal is very high, the reproduction of the modulated carrier signal deteriorates. Stabilized reproduction of the carrier signal is enhanced by a special carrier-level control (CLC) circuit. The principle consists of varying the modulated carrier level in accordance with the direct signal level during the mastering process. Reproduction signal level for channels 1 to 4 is detected with the advance head of the master tape recorder. This passes through an OR gate, a wave-shaping circuit, and a mirror integrating circuit to become the control signal. The control signal is supplied to the CLC circuit and the carrier signal level is automatically adjusted.

Another problem requiring special attention is tracking distortion—the inability of the pickup cartridge to trace exactly the groove waveform. To avoid such difficulties, the groove waveform is compensated for in advance so that proper tracking waveform will be obtained. Called Neutrex, this process actually adds a precise amount of distortion to the record groove during mastering which is opposite and equal to the tracking distortion experienced on playback.

The key element in the playback electronics of a CD-4 system is demodulation. This task can be handled by integrated circuits from Quadracast Systems, Inc., using two of their QSI-5022 chips.

In the demodulator, high- and mid-band expanding circuits are employed with characteristics complementary to the mastering compressors. Deemphasis is also provided for the preemphasized audio signals derived from FM carriers. As with standard disc recording, an RIAA equalization network is provided for reproducing the sum channels.

Required external adjustments to the QSI-5022 chip are a channel separation control and a VCO center frequency adjustment. (A local oscillator, used with the carrier detection circuits, is included on the chip.) Optional adjustments include limiter gain, phase detector balance, and phase-locked loop lock-range. Power consumption is 30 mA at 13 volts dc (typical) and current sinking capability of the chip is 20 mA.

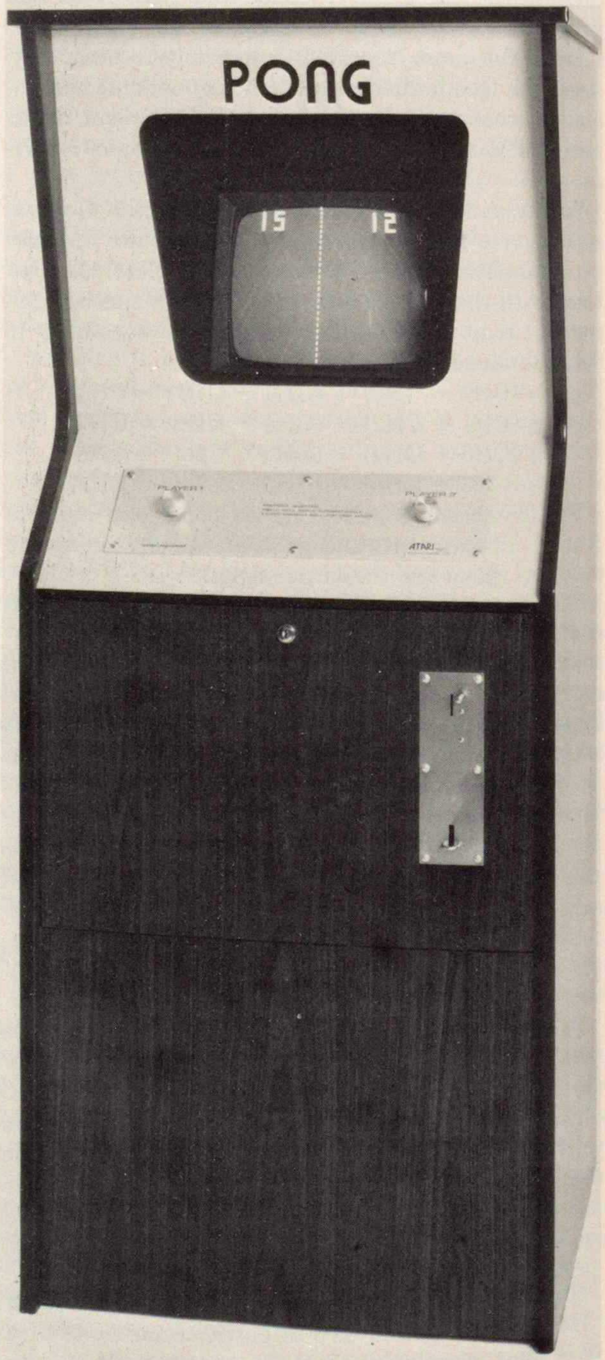
Solid-state chef

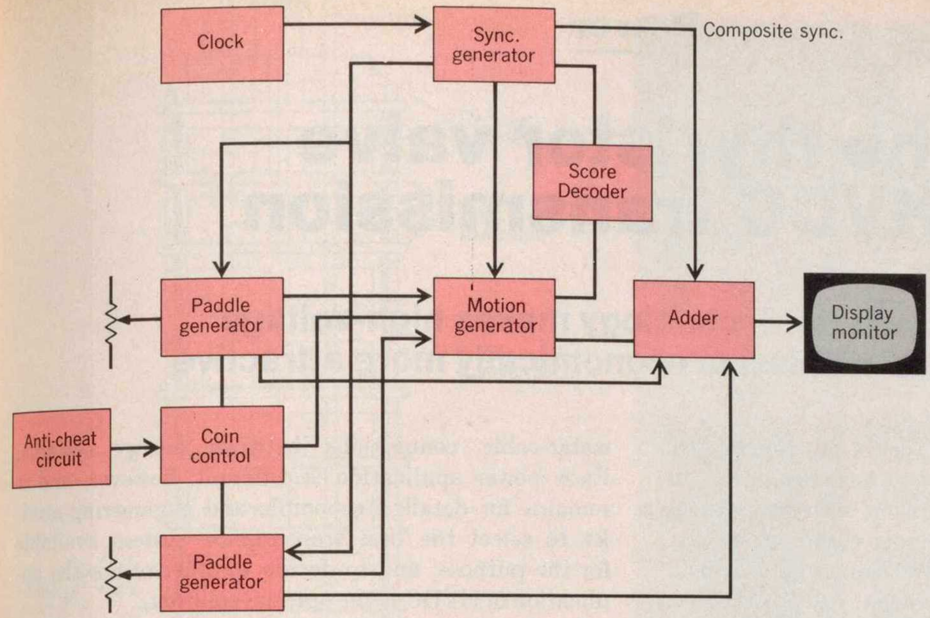
While electricity is an old and dependable friend in the kitchen, solid-state electronics is a versatile and promising newcomer to the art of food preparation. The Frigidaire Division of General Motors has recently announced production of the "Touch-N-Cook" electric range which includes integrated circuit logic, gas discharge readouts, and a unique control system set behind a smooth glass panel (Fig. 12). The retail price of $799, however, may limit the customer base to those families who can already afford to eat out.

Conventional electromechanical components are

[12] Sensors, readouts, and an integrated-circuit microprocessor—all under a flat glass control panel—allow one finger to operate this new "Touch-N-Cook" range from the Frigidaire division of General Motors.

[13] Pong, a first cousin to pinball, is built with standard TTL chips and a consumer-grade TV receiver by Atari, Inc.





[14] **Pong's "brain" generates the visual action while an anti-cheat circuit guards against slugs or line transients. Gone is the "tilt" function since video games work equally well upright or upside down.**

eliminated in the General Motors range allowing just the touch of a finger to initiate cooking, wet timing, or control automatic cleaning of the oven. Errors in setting, which are beyond the range's design limits, are immediately indicated by a flashing display. A double touch of the "off" pad shuts down all cooking functions simultaneously.

Other features include a preheat cycle which is automatically programmed with use of the oven and a cook-and-hold function which keeps food warm for delayed meals.

Programming is straightforward. Cooking a 3-hour roast at 325°F in time for a 6 o'clock meal begins by touching the control surface marked "start time," then the numerals "300." This indicates the oven will start at 3 o'clock. Next touch the control surface marked "oven" and the numbers "325" to set roasting temperature. Finally, touch "stop time" and "600" to turn off the oven at 6 o'clock. From this point on, operation is automatic, having been filed in an integrated circuit memory. Touching "clock" will cause the readout panel to resume showing the correct time.

The proprietary integrated circuit portion of the "Touch-N-Cook" range is a microprocessor developed by American Microsystems, Inc. A similar system has been developed by the RCA Solid State Division, and full details are given in their recently announced application note AN-6096.

ICs on the midway

If electronics has invaded the kitchen, can it be surprising that it has even reached the midway? Pinball arcades—the electromechanical stronghold of buzzers, flippers, relays, and flashing lights—are also feeling the impact of solid-state innovation. During the past year old-line amusement manufacturers have seen "Pong" (Fig. 13), the first success story for video game technology, propel the infant Atari, Inc., to a strong and competitive market position.

Explaining his product, Al Alcorn, chief engineer for the California-based newcomer, says industry-wide flattery now comprises several direct and unauthorized copies of the original Pong.

Unlike typical coin-operated games of skill or chance, Pong has no moving parts other than two rugged, frontpanel potentiometer "paddles" (one for each player). All the action takes place on a recessed TV screen, with the realistic sounds of scoring and bouncing ping pong balls generated electronically.

Conceptually, Pong is the successful interface of computer circuits and an ordinary television set (Fig. 14). Atari uses a black and white Hitachi TV for their video display, and Mr. Alcorn gives the set good marks for reliability under admittedly long and difficult operating conditions. Most field failures involve the potentiometer "paddles," which need replacement about every two months on machines in active locations.

Besides the TV, which Atari buys "as is" and then modifies, Pong contains about 65 integrated circuits in 20 different varieties. All are standard TTL 7400 series chips available from several sources including Signetics, Fairchild, National Semiconductor, and Advanced Micro Devices.

With the success of Pong, Atari has introduced three other video games based on the same principles; Pong Doubles, Space Race, and Gotcha. Atari points out that even doctors and dentists are finding these machines a welcome addition to their waiting rooms where patients have grown restless thumbing issues of *Life*, and the *Saturday Evening Post*.

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