AGC for automatic recording level

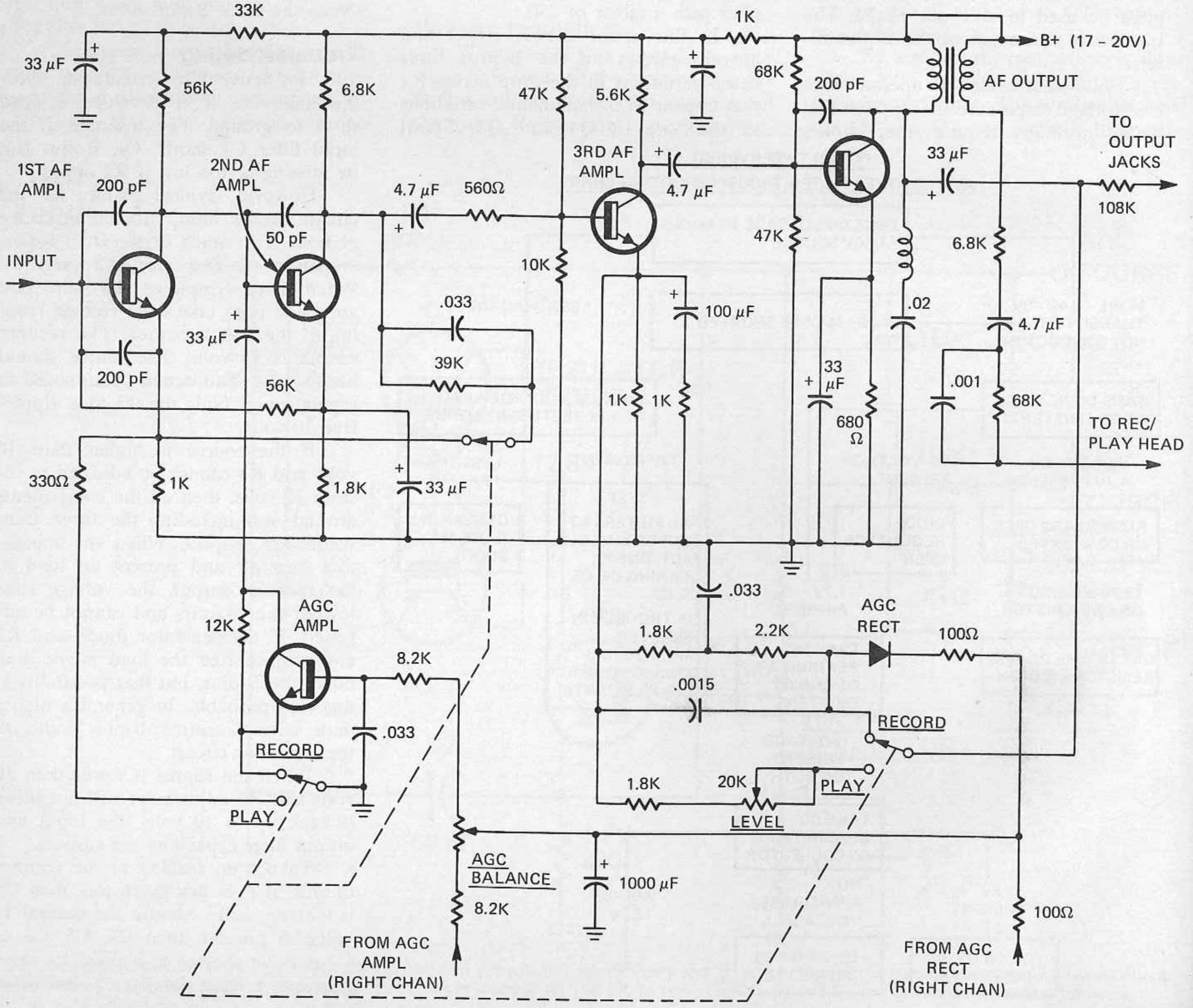
Admiral recorder uses transistor's collector-emitter resistance as heart of its recording circuit.

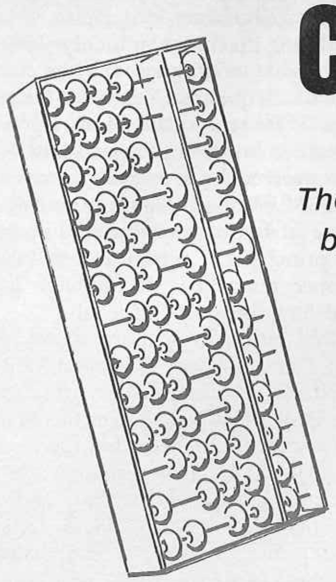
The Admiral model STR901 cartridge tape recorders do not have recording-level meters because the recording level is automatically controlled by an agc system. The diagram shows the simplified circuit of one of the channels of the recorder.

A portion of the signal from the collector of the output transistor is tapped off and rectified by the agc rectifier. The resulting dc signal is filtered by the 1000-μF electrolytic. The AGC BALANCE control determines the amount of the dc voltage that is applied as a variable base bias to the agc controlled transistors. The varying base bias makes the controlled transistor act as a variable control that determines the amount of the signal that will bypassed to ground through the transistor and the 12,000-ohm resistor.

During playback, the adjustable volume or LEVEL controls are switched into the circuits. A portion of the output of each channel is tapped off and fed as negative feedback to the emitters of the third af amplifiers. The out-of-phase signal fed back determines the bias and gain of the third stage amplifier. **R-E**

RECORDING LEVEL is held relatively constant by this circuit. It eliminates the need for a manual input control when recording.

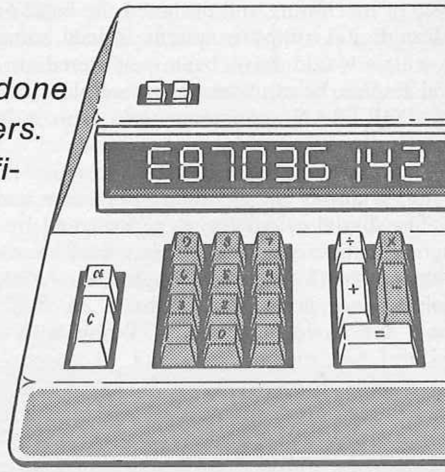




CALCULATORS

The first "digital" calculating was done by early man using his fingers. Then came the abacus and finally the electronic calculator

by FORREST MIMS



from the abacus . . . . to the electronic calculator

IT'S NO COINCIDENCE THAT FINGERS AND THE NUMBERS 0–9 are all referred to as digits because man's first counting machine was his two hands. Finger counting, which is actually primitive addition, is still used throughout the world. But even before recorded history man invented counting techniques which permitted the counting of sums greater than the total of his fingers. Notched bones, marked sticks, and knotted strings made possible more advanced counting, an absolute requirement for time keeping, bartering, and establishing formal commerce.

The earliest mechanical calculator was the abacus. It's believed that the abacus was in use in Egypt as early as 450 B.C., and a type of abacus may have been used in China as early as 600 B.C. The first abacuses consisted of small pebbles moved through grooves drawn in loose sand, and the machine began to bear some resemblance to its modern form when the counting stones were placed in grooves formed in a wood or metal tablet.

The modern abacus consists of a frame which supports a dozen or more parallel rods. Five to seven moveable beads or counters provide the counting mechanism and there is generally a central bar across the top center of the frame to separate one or two beads on each rod from the rest. The beads on top correspond to fives, while the counters below the dividing bar correspond to ones.

To place a number on an abacus, the frame is first cleared by moving all the one's beads *down* and the five's beads *up*. By assigning one rod to be the one's column and those to its left the ten's, hundred's, thousand's, and so forth, it's easy to "write" numbers on the machine by moving the beads toward the central dividing bar.

Arithmetic with an abacus is remarkably simple and efficient, and with practice one can soon gain speed in the ancient art of abacus manipulation. In a now famous competition held in 1946 between a Japanese abacus operator and an American equipped with a mechanical desk calculator, the abacus beat the calculator in four out of five areas of competition. The abacus was faster than the mechanical machine since the operator performs the arithmetic as new numbers are inserted into the machine. In the case of the desk calculator, the operator must activate a total mechanism before the final answer can be calculated, but the abacus provides a running total and the final answer is ready as soon as the last number has been inserted into the machine.

Abacuses are still in use throughout the Orient, the Soviet Union, and other parts of the world. Chinese style abacuses have two beads on the top side and five on the bottom, while the modern Japanese version, the *soroban,* has one bead on top and four below. The soroban is designed for speed and efficiency since elimination of the additional beads forces the operator to "carry" as soon as each column of digits exceeds nine.

The abacus can easily be used for addition and subtraction by a beginner and for multiplication and division after a little practice. But as more advanced mathematical operations were developed a need for more comprehensive calculating machines was created. The first significant step beyond the abacus was a gear driven adding machine invented by Blaise Pascal in 1642. The teen-aged genius designed and assembled a mechanical calculator capable of adding series of eight digit numbers. Another important seventeenth century invention was John Napier's device for calculating with logarithms, and still another was William Oughtred's invention of the slide rule.

The basic concept of Pascal's mechanical adder is found in modern mechanical adding machines, and slide rules are still an important tool of modern engineering. But no inventor foresaw the resolution of the modern calculator as clearly as Charles Babbage.

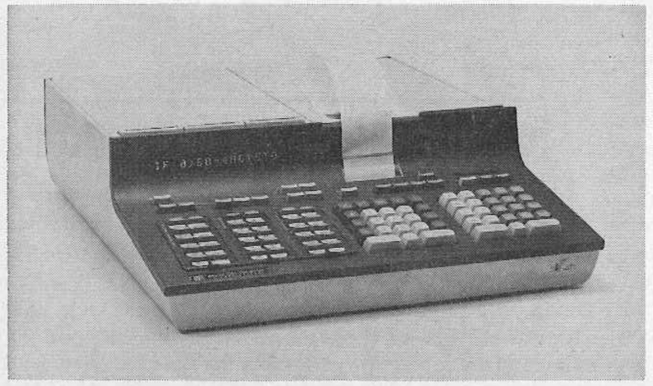
An outspoken English mathematician and philosopher, Babbage was obsessed with the idea of designing and constructing an advanced mechanical calculator which would perform the four basic arithmetic functions as well as advanced manipulations of these fundamental operations.

In 1822 Babbage succeeded in constructing the "Difference Engine" for the solution of polynomial equations ($x^2 + x + a = 0$). The machine's success convinced him that he could construct a more advanced calculator, the Analytical Engine, with a punched card input, a memory of 1,000 50-digit numbers and both visual and hard-copy output.

Unfortunately the machining state of the art in Babbage's time was not sufficiently advanced to permit all the required mechanical parts of his highly complex Analytical Engine to be constructed with the necessary degree of precision. The apparatus required hundreds of precision mechanical components. Though Babbage completed literally thousands of intricate engineering drawings detailing the machine's assembly and internal operation, a feat in itself, the precision tooling required for fabricating the working parts was just not available.

Babbage spent the last 40 years of his life working on the Analytical Engine and died in 1841 without seeing his project completed. He did, however, make important contributions to the science of machining and designed the basic organization of a modern digital computer system. Indeed, some of the operations which would have been performed on Babbage's Analytical Engine bear an amazing resemblance to some of the basic FORTRAN statements used with many modern computers.

By the beginning of the twentieth century the basics of the two major classes of calculating machines had been discovered. The digital calculator, as represented by the abacus and other primitive counting systems, had reached its pinnacle with Babbage's Analytical Engine. And slide rules and Lord Kelvin's tide-prediction machine, an 1872 invention, represented the analog calculators. While both digital and analog calculators were designed to perform arithmetic, and even differential equations in the case of Kelvin's machine, their operation was fundamentally different.



A FULLY PROGRAMMABLE ELECTRONIC CALCULATING SYSTEM, the Hewlett-Packard 9820A, with a built-in printer. This versatile machine represents the pinnacle in electronic desk calculators and offers many of the capabilities of a true minicomputer. The three keyboards to the right of the central arithmetic portion of the machine can be "user defined" by means of plug-in read-only memory modules.

Digital calculators utilize discrete quantities in making calculations, while analog calculators measure or approximate quantities. The differences between the two types of calculators gives each relative advantages and disadvantages. Digital machines, for example, are far more accurate than their analog counterparts and large-capacity digital devices can express answers accurate to one part in a trillion—or better. The accuracy of an analog device will rarely exceed 0.01%.

Analog calculators do have advantages, however, and they are well suited to modeling a complex physical problem and providing solutions to a variety of conditions. In aerodynamics, for example, analog calculators and computers are frequently used to simulate aircraft shapes. By simply turning potentiometers connected to simulate drag, velocity, air density, and other parameters, it's possible to conveniently select optimum aircraft configurations for particular flight requirements.

Getting back to the evolution of calculators, there were a number of important developments at the turn of the century which directly affected future prospects for both analog and digital calculating machines. One of the most important of these was the invention of electrically-read punched cards by Dr. Herman Hollerith. The Hollerith cards were first developed for use in the 1890 United States census and are direct predecessors of the modern IBM card.

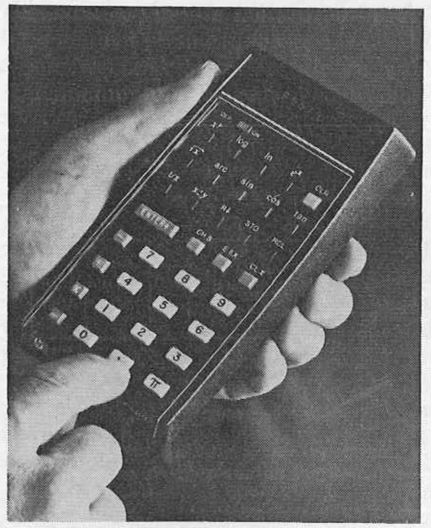
The next big development in the field was the design in 1925 of a large analog computer by Dr. Vannevar Bush. An advanced version of the Bush machine was secretly used during World War II to calculate artillery firing tables. Also in World War II a complex analog calculating system was used in the fire control system of B-29 bombers.

In 1944 interest in calculating machines suddenly shifted from analog devices back to digital techniques with the completion of the Mark I Automatic Sequence Controlled Calculator. Containing more than 3,000 relays, the Mark I could multiply two 23 digit numbers, its maximum capacity, in 4-½ seconds. The Mark I was conceived by Howard Aiken and built with the assistance of IBM. While designing the calculator, Aiken came upon some of Babbage's work and recognized its contribution to the principles of complex digital calculating machines. Aiken once remarked "If Babbage had lived 75 years later, I would have been out of a job."

The Mark I was followed by an even more significant calculating machine. In 1946 Drs. J. Presper Eckert and John Mauchly completed the ENIAC (Electronic Numerical Integrator and Calculator), a significant advance over the Mark I in that it used high-speed vacuum tubes instead of the much slower electro-mechanical relays. The new machine was a major scientific and engineering accomplishment, but it brought along some major problems as well. With 18,000 tubes, 11,000 switches and terminals and more than half a million solder connections, the ENIAC required two and a half years to assemble and more than 1,800 square feet of floor space. But the added complexity gave the ENIAC much faster speed than the Mark I. While the relay machine required a third of a second to add two numbers, the ENIAC could perform 5,000 additions in one second.

The ENIAC marked the beginnings of the computer age, and it was soon followed with high-capacity machines such as the EDSAC (Electronic Delay Storage Automatic Calculator), EDVAC (Electronic Discrete Variable Automatic Calculator) and SSEC (Selective Sequence Electronic Calculator). The EDSAC was unique in that it incorporated a *stored program* for the first time.

The stored program, a key to the success of modern digital calculators and computers, provides the internal instructions necessary for a calculator or computer to perform complex operations with a minimum of outside instructions. A typical stored program, for example, will have the necessary instructions for determining trigonometric functions. The operator is then saved the laborious task of encoding the appropriate instructions each time he needs to refer to such a function. In a typical operation he merely instructs the machine to find the cosine (or tangent or sine) of a particular angle with a few code letters (usually "COS" in the case of cosine) and the machine's internal stored program automatically furnishes the detailed instructions required for the operation to the arithmetic section. Large digital computers frequently use magnetic tape for stored programs, while advanced electronic desk calculators employ solid-state memories for the same purpose.



THE MOST ADVANCED POCKET CALCULATOR made today—the Hewlett-Packard HP-35. This sophisticated electronic slide rule has trig functions, a memory, and can take square roots. It also handles logs and exponential terms. The HP-35 represents a major breakthrough in miniature electronic calculating machines.

In 1951 Eckart and Mauchly completed work on the famous UNIVAC, the first modern digital computer. The original version of this machine was purchased by the United States Census Bureau and was used until 1963 when it was replaced by more modern equipment. The first UNIVAC is now on permanent exhibition along with several other pioneering calculating devices at the Smithsonian Institution in Washington, D.C.

THE CANON POCKETRONIC is the only portable electronic calculator with a paper tape printout. This novel machine incorporates Texas Instruments MOS LSI circuitry but is manufactured in Japan. Texas Instruments also manufactures the semiconductor thermal printout device. The paper tape can be replaced almost instantly by plugging in a new cassette.

During the 1950's the UNIVAC was followed by a series of advanced digital computers developed by the newly founded computer industry.

Though the transistor had been invented in 1948, most computers employed vacuum tubes. But in the late fifties and early sixties reliability of the machines was significantly enhanced when the switch to transistor operation was accomplished. In addition to improving reliability, transistors meant the once bulky computers could be squeezed into much tighter spaces. The size reductions were vital to military and civilian aerospace endeavors and for the first time it became possible for an aircraft or missile to carry along its own portable digital computer for inertial navigation and other important roles. These early avionics computers were primitive by today's standards, but they represented an enormous step forward at the time of their introduction.

The semiconductor developments which made possible compact digital computer systems led to speculation about the prospects for electronic desk calculators. Integrated circuits had been invented by Texas Instruments in the late 1950's, and major technology improvements by Fairchild a few years later made possible the formation of several dozen electronic components on a single silicon substrate. Since even the first IC's crammed tens of components into the space normally required for one and since the components were all connected together within the IC itself, for the first time it became feasible to consider designing electronic desk calculators. But the development which began a literal explosion of electronic desk calculators was the *L*arge-*S*cale *I*ntegrated circuit (LSI). A product of metal-oxide semiconductor (MOS) technology, LSI made possible the compression of the hundreds or even thousands of transistors and other components required to perform the computer operations of arithmetic, memory, and control onto several semiconductor chips each about a tenth of an inch square. With the availability of calculator "chips" it became feasible to manufacture multiple-function electronic desk calculators that required less space than a telephone.

A size comparison between a modern LSI calculator and the first vacuum-tube calculator, the ENIAC, is truly impressive. Where the ENIAC required an entire room to house its racks of 18,000 vacuum tubes, a miniature LSI calculator containing the equivalent of 30,000 transistors will easily slip into a shirt pocket.

Continued developments in LSI technology have dramatically improved electronic calculators. Now, for example, nearly all the electronics required for a basic four function calculator (+, –, ×, ÷) can be placed on a single LSI chip. The result is calculators no larger than a portable transistor radio. In addition to LSI, these new calculators employ such recent developments as light-emitting diode (LED) displays and thermal printers. The market is highly competitive and more than a dozen firms produce the miniature machines.

Most miniature calculators employ LED or liquid-crystal displays, but there is one unit which provides a paper tape printout. Dubbed the Pocketronix, the machine represents a joint development by Texas Instruments, Inc. in this country and Canon, Inc. of Japan. The Pocketronix employs three LSI chips and a unique semiconductor thermal printer manufactured by Texas Instruments. As operations are pressed onto the keyboard, the entries, function signs, and results are immediately printed onto the cassette-loaded paper tape.

Another impressive miniature calculator is the HP-35. Manufactured by Hewlett-Packard, a major producer of programmable scientific desk calculators, the HP-35 has memory capability and can provide trigonometric functions, logs, pi, and square roots at the touch of a single function key. Since the HP-35 literally fits in a shirt pocket, it represents the fulfillment of many science-fiction predictions.

Miniature calculators are popular with students and anyone else requiring math assistance on-the-go, but for desk operation machines about the size of a cigar box are standard. Dozens of different types from as many manufacturers are now available and the perspective purchaser can choose from units that include such added features as memory capability, printers (electronic and electromechanical), special functions, and novel keyboard manipulation shortcuts.

A LATE MODEL DESK CALCULATOR, the Friden EC1117 has memory capability. Low-cost machines like this are popular with businesses. Friden also manufactures printing calculators and all electronic cash registers.

Prices for miniature and desk calculators begin at just under $100 and range up to several thousand dollars for a machine equipped with a printer and peripheral equipment. As with any other purchase, the buyer gets what he pays for and the cheaper machines do not necessarily represent the best bargain. Many of the low-cost machines require special keyboard manipulations to perform simple problems in addition and subtraction.

A possible solution for the prospective purchaser with a limited budget and soldering iron experience is one of the new kit calculators. Micro Instrumentation and Telemetry Systems, Inc. has been selling kit desk calculators since 1971 and now offers a line of machines ranging from a miniature machine to full function scientific calculator. Heathkit brought out a kit calculator in 1972, and the May 1972 issue of **Radio-Electronics** featured a construction article on a kit pocket calculator manufactured by Alpha Research Corporation.

Kit calculators are not difficult to assemble. Besides saving money, assembly of a kit machine provides background for future troubleshooting and enhances the kit builders' knowledge of general calculator construction and operation.

The development of other specialized calculator chips, particularly memories, has further enhanced calculator performance and now several companies are marketing *scientific* calculators. These machines include the standard four arithmetic functions on their keyboards but supplement the basic capability with keys for the various trigonometric funtions, pi, square and square root, e^x, logarithms, and other operations common to mathematics. In this way, the scientific calculator becomes an instant access book of mathematical tables as well as an easy operating calculating machine.

THE CANON PALMTRONIC LE-10 has an LED display and rechargable batteries. To extend battery life, which is indicated by the built-in meter, the LED display turns off after about half a minute. Note that the machine incorporates separate keys for each function, a desirable feature not often found on miniature calculators.

The scientific calculator has the ability to perform complex operations as a result of the same kind of internally stored program used in large scale computers. Read only memory (ROM) chips store the microinstructions necessary to tell the calculator's arithmetic unit to calculate the desired mathematical function. Since the expanded capability of the scientific machines is in large part dependent on the capacity of the ROM, its possible to further expand an existing machine by merely adding plug-in memory modules. Several manufacturers offer scientific calculators which are compatible with a variety of memory modules which let the operator literally custom-design his own keyboard in the time it takes to insert the module into the machine. A bank of unmarked keys is used to specify the operations and functions contained within the special ROM modules, and a snap-in label card notes the newly assigned function of each key. The calculator can be "redesigned" in the time it takes to exchange the ROM modules.

In what has become one of the fastest moving fields in electronics technology in recent years, scientific calculators have led to the next logical development—the programmable calculator. With the operating ease of a calculator and the power of a small computer, programmable calculators fill an important gap between scientific calculators and minicomputers.

It's important to understand the difference between the programmable calculator and the minicomputer. In the important area of operational ease the calculator has the unquestioned lead. Programmable calculators with an algebraic keyboard can handle complex equations just as they are written on paper while a computer program must be written before the minicomputer will handle similar problems. Cost is another important area where the calculator comes out ahead. Programmable calculators can be purchased for about $3,000, and $10,000 will buy a fully expanded model with accessories such as additional memory, printer, plotter, and input devices. The price may seem high to the uninitiated, but the calculating power makes it a genuine bargain.

WANG SERIES 100 ELECTRONIC DESK CALCULATOR. Manufactured by the first company into the electronic desk calculator business, the machine includes scientific and statistical keys as well as interfacing for an optional printer. The display panel is on an axle and can be rotated for convenient viewing by the user.

For those who cannot afford the price of a programmable machine but are eager to have one anyway, help is on the way in the form of a kit programming unit. MITS, Inc. plans to bring out a programmer kit which can be mated to its machines already on the market. The cost for a complete kit programming unit and calculator will be about a tenth of a corresponding assembled unit's cost. A MITS 7400 series scientific calculator and programmer will provide the technician, engineer, or experimenter with many of the capabilities of a minicomputer.

So there you have it. The primitive abacus, the 3,000 year old digital calculator still being used throughout the world, has finally been outclassed by electronics. In a development which would have been labeled as science fiction just 10 years ago, complete programmable calculating systems which fit on a standard desk top and multiple function machines which fit in a shirt pocket are available today. **R-E**

ARC-OVER IN BRIGHTNESS CONTROL

I'm getting arc-over in the brightness control of an Electrohome Viking TV, TCO-299R. I can't understand it. Shouldn't be any really high voltage around there.—E.B., Minden, Ont.

Right. There should be no more than + 135 volts on this control, and this won't arc to anything, unless it is very close indeed. There is one possibility: internal arcing in the pix-tube might cause it. Try tapping the neck carefully with a pencil eraser and watching for arcing inside the tube.

You might try adding an "arc-gap" to the pix-tube socket or wiring. Check the pix-tube for internal shorts. If you find one, say between G1 and the focus or screen grid, try this: place the tube face down on a pad and rap the neck (carefully!). This will sometimes dislodge small particles which cause the short; they'll fall into the bell where they won't hurt anything. If this fails—new tube.

USING THE COLOR-BAR GENERATOR

Trying to service a color set without a color-bar signal can be an exercise in futility

by FOREST H. BELT and ESTILLE DOBSON

A VIDEO PATTERN OF DOTS, LINES, AND crosshatch is the standard for converging color sets. That kind of generator has been around since color first came out. For color-circuit work, NTSC color bars were added. Only later did the keyed-rainbow color pattern come into vogue in their place. Today, the keyed rainbow is by far the more popular.

You can track down many chroma faults with a station signal. But the job is difficult because levels of chroma change from scene to scene. A keyed rainbow signal produces a steady display of ten color bars. When you study the screen or trace with a scope, you know what to expect. That makes it easier to spot when something's wrong, and to analyze what the trouble is.

A keyed-rainbow generator

To make a rainbow on the color picture tube, a generator modulates an rf signal with an offset subcarrier at 3.563795 MHz. That's offset from the color subcarrier, 3.579545 MHz, by the horizontal line frequency. (A few modern instruments use other offset subcarrier and horizontal-line frequencies, but operation is essentially the same as with this popular version.)

The 3.56-MHz signal goes to the receiver demodulators. There it is compared with a 3.58-MHz reference signal. Their mixing creates a continuous change in demodulator output phase that totals exactly 360° across each horizontal line. The output shift produces one complete "rainbow" of colors during each line.

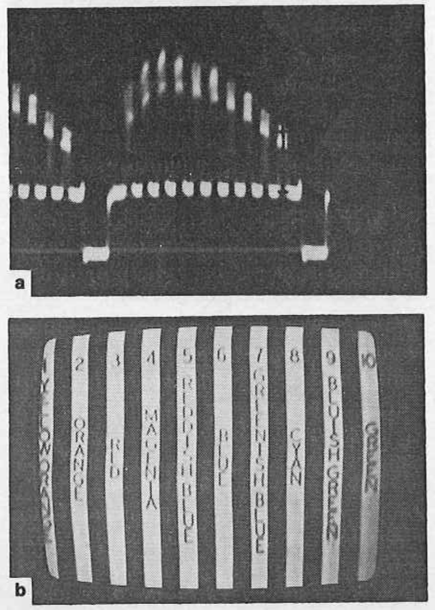
That makes a solid rainbow raster, *not* rainbow bars. So, the 3.56-MHz oscillator is shut off and keyed back on 12 times during each horizontal sweep. Those blank spaces interrupt the rainbow at 30° intervals, keeping it off for 15° each time. Off-time shows black on the TV screen, breaking the rainbow into bars.

Fig. 1-a shows the 12 bars that key the rainbow signal. Fig. 1-b shows the color-bar pattern on the color picture tube. The bar colors are labeled. Remember especially the positions of the red bar, third, at 90°; blue bar, sixth, at 180°; and green, tenth, at 300°.

Note that, of the twelve bars in the signal, only ten appear as color bars on the TV screen. This is because two of them fall during overscan. They are hidden at the sides of the screen. One is on the back porch of the horizontal sync pulse and acts as the color-sync reference burst; it triggers the 3.58-MHz color oscillator in the receiver.

For servicing, you need a way to find out if a set can hold color on weak signals. For this, some generators have a control for reducing color-signal level without lowering the rf output. You turn the color level down to check for poor color sync. Tune the station selector off-channel and back several times. Color should lock in solid every time, without delay.

FIG. 1—KEYING GENERATOR'S OSCILLATOR on and off makes the bar signal at (a). Only ten bars show on the screen (b), two are lost in overscan.



You can turn the generator's color level up higher than normal to force stability while you troubleshoot a set you know has poor color sync. This gives you a constant signal level to work with in color-sync or automatic color control circuits. Without this strong input, the color-sync signals may fluctuate and you can't get a steady voltage or scope waveform to measure. Too, you can check how well the acc (automatic chroma control) handles signal variations.

In the color stages

Suppose you suspect a color amplifier. Inject the keyed-rainbow signal, on its rf carrier, into the antenna terminals of the TV set. You can spot a dead chroma stage or loss of gain readily. Just scope the waveforms at the input and output of each color amplifier stage.

But the solution isn't always that simple. You can find an inoperative color amplifier but still not know whether the fault is there or in the color killer. Improper bias from the killer may be cutting the amplifier off.

There's a way to find out. Fig. 2 illustrates. Connect the negative lead of a variable bias supply to point Q, positive lead to ground. Set the bias knob to 6 or 8 volts. There should be no color in the bar pattern on the picture tube. Turn the bias knob down until you're applying only 0.5 volt of negative bias to the grid of the first color amplifier. That should bring out a good strong display of color in the bars.

If decreasing artificial cutoff bias lets the color amplifier work, the cause for it not working must lie in the natural bias-voltage source. Color-amplifier bias comes from the acc/killer system. So that's where to look for the defect.

Color bars tell you more. From