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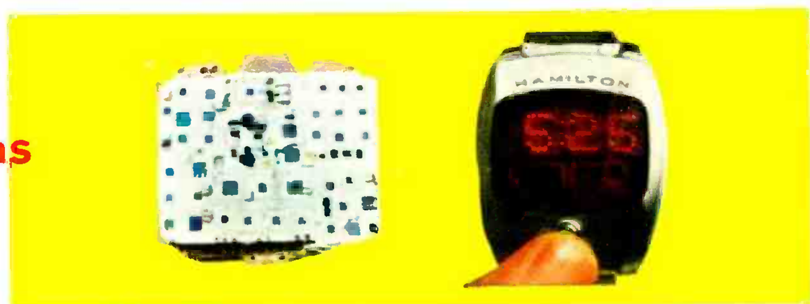

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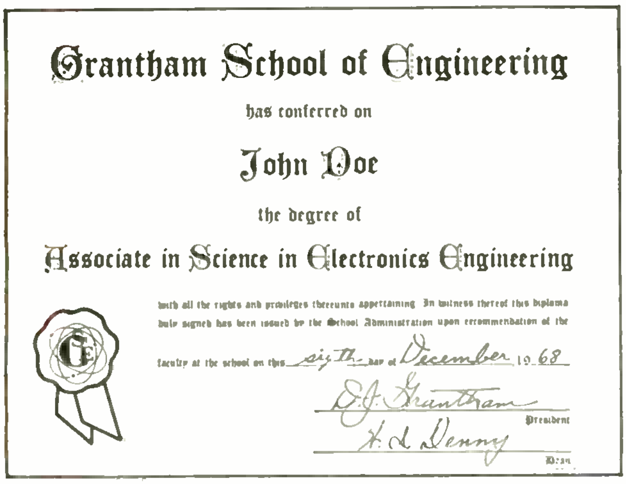

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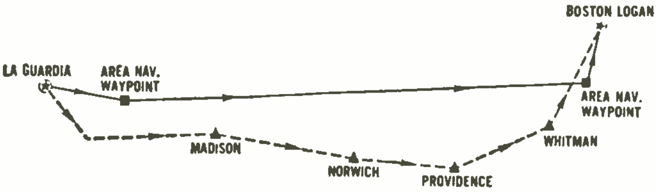
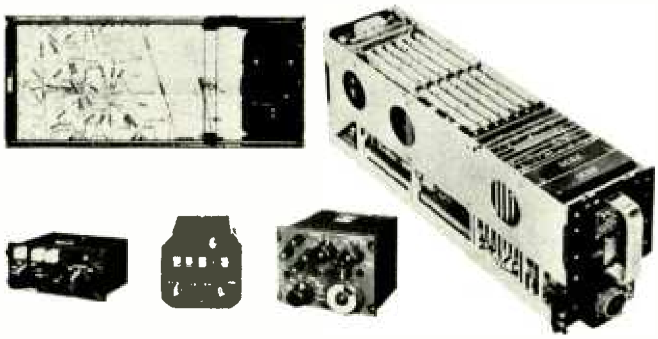
NEW & TIMELY

Volume 41 Number 8 RADIO-ELECTRONICS August 1970

AIRBORNE COMPUTER TO GUIDE SHUTTLE JETS



Area navigation vs. conventional navigation (dashed line) from New York to Boston. Below, the display chart and (left to right) autopilot controller, distance/time display, computer control and computer.



NEW YORK—Eastern Airlines' Air-Shuttle jets operating into Washington. Boston and New York-area airports this fall will use a computerized navigation system to fly shorter, less congested routes.

Pilots will not have to thread their way from one navigational radio station to the next. Traffic now must slow down when aircraft on the same or intersecting routes overfly radio stations.

The system, called Omnitrac, uses a 4096-word, 50-byte digital computer that accepts radio signals from FAA radio stations (or other navigation inputs) and continually plots the aircraft's position on a moving chart. Pilots can see range and bearing to points along the route by selecting the geographical position on the computer control 12-key turret switch. Each digital key defines preselected points. The autopilot control unit couples the computer-based navigation signals into the aircraft's autopilot.

Eastern is buying the system from Decca Navigator Co., a British firm.

Las Vegas—Some 300 radio-controlled, scale-model aircraft will be matched in international competition here September 4–7. Race officials predict world speed records will be broken as the R/C models approach scale speeds of 200 mph. Over $6,000 for prizes is being offered by the Mint Hotel, sponsor of the event.

APOLLO 13 OVERLOAD

HOUSTON—An overload of voltage applied to two heater switches in an Apollo 13 oxygen tank apparently caused the explosion aboard the spacecraft. The overload occurred during an attempt to drain the tank prior to the April 11 blastoff.

Because of difficulty in draining the tank, 65 volts dc was applied to the thermostat switches, which were designed for 30 volts. This apparently fused the switches, causing heaters to slowly bake away wire insulation and cause a short circuit.

NEXT MONTH
Build a computerized IC music synthesizer.

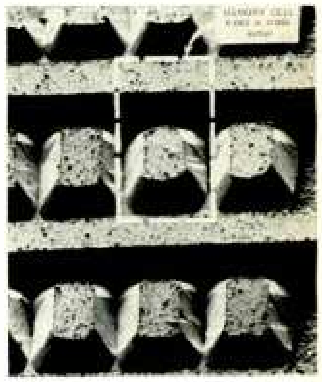
DIODES USED IN HIGH-DENSITY IC MEMORY

MURRAY HILL, N. J.—The tiny memory cell shown in the scanning-electron-microscope photo is a new IC type under development at Bell Labs for future telephone switching systems.

Each .003 x .005-inch cell in the IC array is a reverse-biased Schottky diode connected in series with a diffused pn junction diode. A large or small charge (1 or 0) is placed on the reverse-biased diode. Each bit must be replenished every 1/20 sec as the charge dissipates.

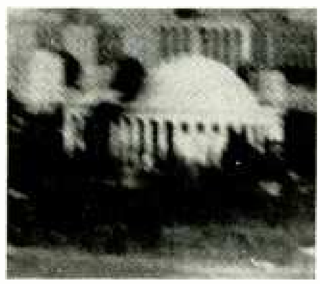
The design is called "charge transfer diode memory" since the charge is temporarily transferred to the other diode during read and write operations. Cells are arranged in an x, y structure using a metal beam for "x" and a silicon bar for "y." Readout is accomplished by detecting the charge stored in a cell by sensing the foward charge flow through the x, y leads in response to interrogation pulses. Bell predicts read speed rates to 50 billionths of a second.

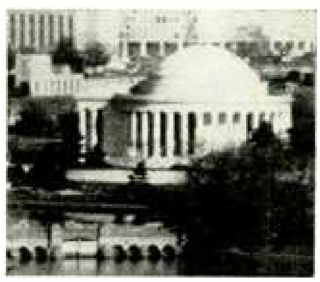
A memory capacity of 100,000 bits per square inch may be possible, according to



Bell. The company is looking for better memory systems to handle the information that must be stored for telephone calls. Two 10-digit phone numbers (for the called and calling subscribers) require at least temporary storage of some 80 binary digits.

(N & T continued on page 6)





A miniature electromechanical servo system attached to a camera in a helicopter made the dramatic difference in these photos of the Jefferson Monument in Washington, D.C. The shots were taken with a 400-mm lens at 1/50 sec, but helicopter jiggling and vibration was sensed by two tiny gyroscopes mounted in a bellow-like collar in front of the camera lens. The cylindrical, fluid-filled bellows has glass discs at each end. The bellows, therefore, is an optical element whose refraction angle can be changed by bending the glass discs in response to signals transmitted from the gyros. Dynasciences Corp., a Los Angeles firm who have aimed their sales at the military, movie and TV industries and law enforcement agencies, is developing a less expensive version. One of the image stabilizer systems is shown above mounted on a 35-mm Arriflex camera.

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TELEVISION

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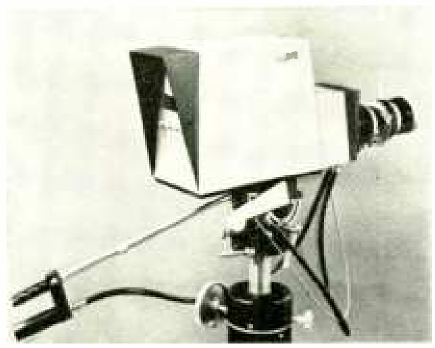
. . . **see page 46**

Portable vtr's give you up to $\frac{1}{2}$-hour of "point-and-shoot" electronic photography. Find out how the latest models work.
. . . **see page 9**



Color TV cameras used to carry five-figure price tags until this one-tube model hit the market. How long before under-$1,000 versions are available?
. . . **see page 30**

DEPARTMENTS

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LOOKING AHEAD

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

The new color sets

As promised, the 1971 model year will be a year of more-than-usual innovation in U.S.-manufactured color TV. Though nothing startlingly new has appeared yet, almost every television set manufacturer has adopted several advanced concepts in an attempt to get consumers back into the TV-buying mood.

Although not all TV set lines had been previewed at our press time, it is now clear that several major trends are sweeping the industry, including: (1) The new super-rectangular picture tube sizes. (2) All-electronic varactor tuning. (3) Flesh-tone correction systems (such as Magnavox's TAC) under a variety of proprietary names. (4) Heavier use of solid-state devices, including more all-solid-state chassis.

Those new picture tubes

The new square-cornered tubes, measuring 19, 21 and 25 inches in viewable diagonal, have an aspect ratio of 4-by-3, the same as the transmitted image. Their surface is flatter and they present a more pleasing picture. Two North American manufacturers have introduced lines using all three new sizes—Electrohome of Canada and Magnavox. Zenith is using both the 19- and the 25-inch, and most of the others have the 25-inch only but plan to introduce the other sizes later.

Magnavox has made the most extensive switchover, almost completely replacing its 18- and 20-inch models with 19- and 21-inch sets and featuring 46 of the new 25-inch sets as compared to only nine with 23-inch screens. In most lines the 25-inch tube takes over in the top-of-the-line area, replacing all 23-inch models beginning in the area of $600 to $700 list price.

The various black-matrix or black-surround phosphor techniques are becoming more widespread, particularly in the 25-inch tube. In addition to Admiral, RCA and Zenith, Sylvania has now added its own "black composite" system.

Electronic tuning

Sylvania is the first U.S. manufacturer to begin shipping sets with all-electronic varactor tuning for all channels, but others will follow closely. The Sylvania system, currently using many German-made components, uses 11 vertically grouped pushbuttons, each of which can be preset to any vhf or uhf channel—in effect 11 individual all-channel tuners. Pushing any button immediately brings the corresponding channel into view—the tuner doesn't run successively through intermediate channels. Each set is shipped with 82 die-cut channel indicators. When the tuner is set up for local conditions (generally by the dealer), the proper channel numbers are inserted into a transparent sleeve alongside the pushbutton bank. Sylvania's electronically-tuned sets, with 25-inch tube and solid-state chassis, will start at a suggested list of $725.

Zenith promised late summer delivery of its own varactor-tuned set. This one uses a pushbar to bring in up to 14 vhf and uhf channels in any prearranged sequence, for tuning either at the set or remotely. In other models, Zenith also continues its mechanical uhf detent tuner which clicks any six uhf channels into position in the same manner as standard vhf tuners now on the market.

Philco-Ford attacks the problem of difficult uhf tuning with an electronic uhf tuner combined with mechanical vhf tuning in two of its models. The new tuner may be preset to any six uhf channels, using buttons which merely have to be touched (not pushed) to tune the channels in any sequence. Philco also introduced a six-detent mechanical uhf tuner, as did RCA.

Toward automatic color

No-hands color control is obviously the goal of set manufacturers, and most of them are using some form of flesh-tone corrector in combination with AFC and automatic chroma control. Last year the flesh-tone corrector was a selling point for Philco-Ford and Magnavox. This year, Zenith has its similar "Automatic Tint Guard," Admiral its "Color Monitor," RCA its "Accu-Color," and so forth. Japanese manufacturers appear to be approaching the question in a different manner, through preset controls. Hitachi, for example, has a feature called "Automatic Picture Setting." Color, tint, brightness and contrast are preset at the factory (and can be reset by the service technician) for optimum picture. The viewer may override the factory settings and adjust the picture manually.

Another new circuit has been added by Philco-Ford to its "Cosmetic Color" tint adjustor. This is called "Automatic Color Balance," which is controlled by the color burst signal and monitors the green-to-blue ratio. When a color signal is being received, it automatically adds emphasis to the green portion of the signal, eliminating bluish tinges to solid-green areas, such as football fields. When a black-and-white signal is being received, the circuit steps up the blue to avoid a sepia tone on the picture.

Solid-state developments

At least three new all-solid-state chassis will appear in the 1971 color models. Zenith hasn't yet announced details, but it will have one making extensive use of its "Dura-Module" connecting system and more advanced IC's. Zenith's 19-inch chassis is a new hybrid with only four tubes. It has four ICs and uses a solid-state, high-voltage tripler rectifier system.

Sylvania, which uses tripler rectifiers in most sets, employs its first all-solid-state chassis in its high-end 25-inch sets. It has four i.f. stages and uses plug-in transistors for easy replacement. RCA has redesigned its solid-state chassis, which it now features in sets starting at $649.95; it slides from the rear of the set for servicing.

New warranty war?

Most TV manufacturer warranty plans seem to satisfy no one. RCA's new Purchaser Satisfaction (PS) policy for its 1971 lines is designed to make everyone happy, including both the consumer and the service technician. It extends the guarantee on 23- and 25-inch solid-state color sets to one full year's labor, providing 90 days' labor on all other products. The intriguing aspect of the plan is that it gives the set owner freedom of choice in selecting his repair agency. The service dealer performing the work submits this bill, at the regular rates, to any of 21 district warranty offices for payment. (Portable radios, phonos and recorders, which have a 90-day, over-the-counter exchange warranty, are excepted.) **R-E**

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SYSTEM CONVERTS TEXT TO SYNTHETIC SPEECH

MURRAY HILL, N. J.—Speech researchers and engineers at Bell Labs have devised a computerized system for converting printed text into synthetic speech. The text-to-talk conversion includes a computerized approximation of the complex rules of timing, pitch and stress people use in everyday conversation.

A passage sent to the computer via a teletypewriter has timing and stress assigned to each word by the computer, which then finds a phonetic description of each word from a dictionary stored in the computer memory. Also stored are mathematical approximations for the shapes and motions the human vocal tract makes. Mathematical descriptions of vocal-tract motions are computed and used to generate electrical speech signals. An oscilloscope displays the changes that occur in a model vocal tract as the computer "reads" the passage.

Applications? Bell says the system may someday be useful for automatic information services with extensive vocabularies. Doctors could have a page recited from a medical textbook, or a stock manager could get information on a company inventory. An aid for the blind and programmed instruction are other possibilities.

TRANSMITTER TO AID APOLLO EXPLORATION

NEW YORK—A briefcase-sized transmitter/receiver is being developed by RCA for use on the lunar surface. The battery-operated, 10-watt system will permit astronauts to communicate with earth-based stations without the signals being relayed through the Lunar Module. An umbrella-like, 38-inch diameter antenna will eliminate the need for one astronaut to remain within sight of the LM. The antenna can quickly be deployed as the astronauts explore the lunar surface.

The system will be designed to be mounted on the Lunar Rover vehicle, slated for use on Apollo 16. In addition to providing TV viewers with scenes of the lunar exploration, the system may be used to send a colorcast of the LM's blastoff from the moon's surface.

Automated health screening system rapidly collects and records medical data while you recline in a special contour chair. Introduced recently by the Chicago-based International Health Systems, the new Computa-Lab is designed to accurately measure basic parameters of the human body at low costs. Mobility for the module was achieved by using smaller medical test components that are linked to a sequential switching mechanism. A technician can screen two persons in 30 minutes, obtaining, with other data, a record of sight, pulmonary function, respiration, a phonocardiogram, electrocardiogram and electrocardioanalysis.

"Hands-Free" phone, one of some 100 being installed in New York City, is put to use at Grand Central Station. A recessed microphone, protected by a grille, is used for speaking, while a loudspeaker in the ceiling of the booth lets you hear the party you've called. A volume control is provided for the loudspeaker. The hand-free phone trial is an attempt to eliminate vandalism.

CARTRIDGE COLOR TV

A home cartridge color TV system for under $900 will be marketed by Cartridge Television Inc., an Avco Corp. subsidiary.

The unit consists of a cartridge video tape deck combined with a color TV receiver. Blank tapes will cost under $8 for 30 mins. Full-length movies for rental at $3 are planned. (Avco owns Embassy Pictures.)

Avco is reportedly readying a California plant.—R-E

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Inside Portable VTR's

by G. McGINTY

Portable video tape recorders pack a lot of sophisticated electronics into small shoulder packs. Here's how the latest models work

ELECTRONIC PHOTOGRAPHY BECAME A REALITY A FEW years ago when some inventive engineering freed helical-scan video tape recorders from their ties to the power line. These portables give nearly all the freedom of hand-held movie cameras with such extras as fully automatic audio recording, 20-minute (and now ½-hour) recording time, fully automatic "point-and-shoot" operation, and no waiting for processing.

The latest versions, now hitting the market, have such added features as powered rewind, fast-forward and *playback* with the picture appearing in the viewfinder.

One portable now on the market is the Sony DVK-2400. The shoulder pack contains the ½-inch helical-scan vtr powered by sealed lead-acid storage batteries that provide a running time of about 1 hour. The tapes last 20 minutes, so there is plenty of energy for setting up operations and making two tapes. The deck contains the tape transport, automatic-video and audio-record circuits, the servo system that drives tht tape transport and the scanner (which contains the rotating video heads).

The camera uses a small (⅝-inch) separate-mesh vidicon and is equipped with a 4-to-1 zoom lens as standard equipment. It operates like a fully automatic "through-the-lens" camera, since the viewfinder is actually a 1-inch TV screen that displays the video being sent down the connection cable to the recorder (see photo). Recordings are started by pulling the trigger on the hand grip.

Some operating signals to the camera man are: a red light in the eyepiece to show when recordings are in progress (tape moving); low battery-voltage alarm (the viewfinder's raster goes out of focus) and tape run-out alarm (the viewfinder's raster goes out).

The captive-camera idea

In most video tape recorders the servo system times the rotating video heads in the scanner to start their swipe across the tape in synchronism with the start of a vertical field. The idea is to get the heads at the right place at the right time. To do this, the vtr locks on vertical sync pulses that are part of the incoming signal. These vtr's make use of the 60-Hz power line to drive the tape transport at the right speed and to get the scanner (rotating heads) in the right ball park in terms of rotating speed.

The servo system in the portables is much simpler. It simply makes the scanner rotate at the right speed and pays no attention to input signals. However, the scanner generates sync signals to drive the camera. In this way, when the rotating video heads come into position to start a swipe across the tape, a sync pulse is sent to the camera and the camera starts a vertical field. The term "captive camera" is used to describe this mode of operation. Its advantage is that the servo system in the vtr becomes a very simple speed regulator and nothing more.

The basic concept of the speed-regulating servos used in helical-scan vtr's is in Fig. 1. A dc motor drives the scanner directly. The scanner contains the rotating video-head assembly. Most portables are two-head machines. Here each head is in contact with the tape for half a revolution. Since the head must traverse the tape in the time taken for one vertical field (1/60 sec), half a revolution takes 1/60 sec and a full revolution takes 1/30 sec. Thus the correct rotating speed for the scanner is 30 rps, or 1800 rpm. An iron vane on the scanner assembly cuts the fields of a pair of pulse coils to generate 60-Hz sync pulses for the camera. The pulse coils are positioned so that the pulses are generated when the video heads start their swipe across the tape.

A tone generator connected to one end of the motor shaft generates feedback signals for the servo system and, as a byproduct, 15,750-Hz sync signals for the camera. The tone generator is usually an iron wheel with 525 ridges

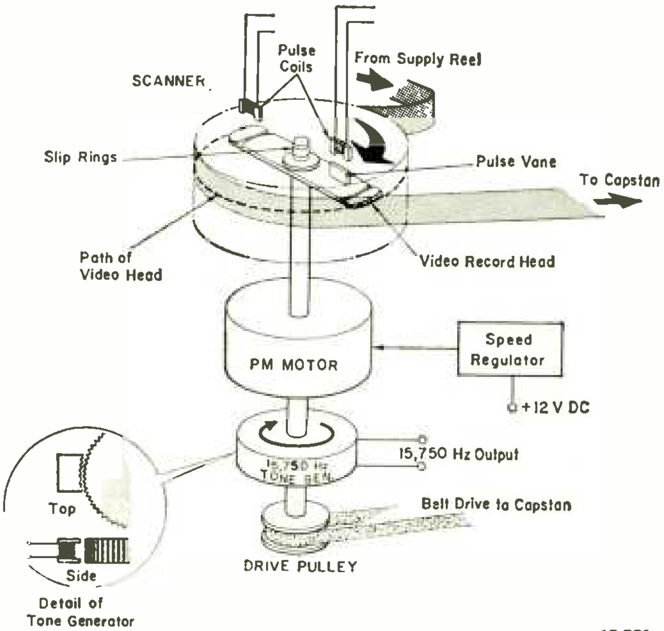
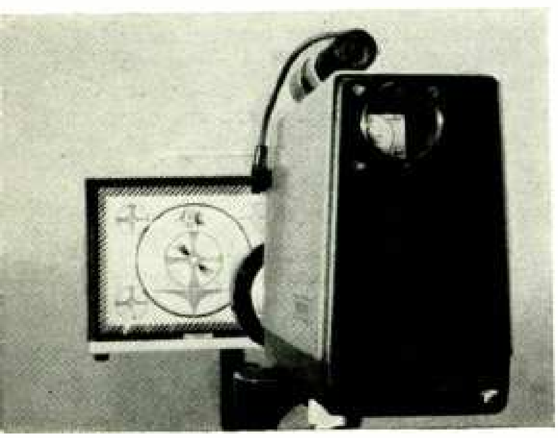


FIG. 1—SIMPLIFIED VIEW of video scanner assembly. A 15,750-Hz signal is fed from tone generator as the 525 iron ridges on the wheel rotate at 30 rps near the mating pole piece.



TV SCREEN serves as viewfinder in Sony DVC-2400, showing the picture being sent to the portable vtr. (Eyepiece removed from camera.)

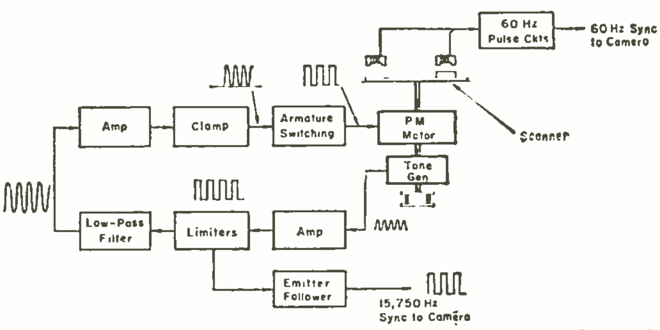


FIG. 2—SERVO SYSTEM used in the Sony DV-2400. System's speed reference utilizes the slope of a low-pass RC filter.

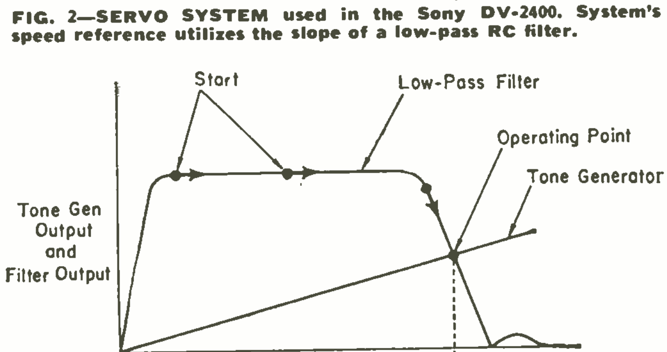


FIG. 3—OPERATING CHARACTERISTICS of servo. Tone generator output is superimposed on frequency vs output curve.

milled into its edge (see detail in Fig. 1).

A mating pole piece, through which direct current flows, generates sinusoidal signals as follows. When the ridges on the wheel line up with the ridges on the stationary pole piece, the magnetic reluctance of the system is minimum and the coil has maximum inductance. Similarly, inductance is minimum when the peaks on the wheel are opposite the valleys on the pole piece. Since the wheel rotates at 30 rps, the 525-tooth arrangement produces a $30 \times 525 = 15{,}750$-Hz signal (when the scanner is rotating at the correct speed).

Speed control is achieved by comparing the output frequency of the tone generator with some sort of frequency reference. The result of this comparison is used to control the rotation of the drive motor, a dc motor with a permanent-magnet field. The way in which the comparator works differs between units, so let's look at the servo systems in detail.

Sony DV-2400 system

Fig. 2 shows the block diagram of the speed-regulating servo used in the Sony DV-2400. This unit employs a unique speed reference. It is actually the slope of the high end of a low-pass filter. Since the filter (a bridged-T arrangement) uses RC components, the frequency reference is independent of variations in battery voltage, temperature or other environmental factors.

Operating characteristics are shown in Fig. 3. The straight-line characteristic is the speed-vs-frequency graph of the tone generator. It's a simple ac generator, so output frequency is directly proportional to speed. This graph is superimposed on that of the frequency-vs-output curve of the low-pass filter.

When the power is switched on, a capacitor charging into the input of the armature-switching circuit applies a burst of armature current for the motor and it accelerates rapidly. At low speeds the amplified and limited output of the tone generator produces maximum output from the low-pass filter.

This results in maximum drive to the armature-current control circuit and the motor continues to accelerate. As speed approaches the correct value, output from the low-pass filter begins to fall and armature current follows suit.

A stable operating point is reached where the tone generator's graph crosses that of the low-pass filter. Here an increase in speed (that might result from installing freshly charged batteries) results in less output from the low-pass filter. A drop in speed (caused by increased mechanical loading when tape begins to move) causes an increase in filter output and a corresponding boost in armature current.

In this way, scanner speed is held within narrow limits despite variations in battery voltage and mechanical loading. Tape speed is also constant as the same motor that drives the scanner directly, drives the capstan through a rubber belt.

The series of limiters ahead of the low-pass filter eliminates amplitude variations so that only frequency determines the output of the low-pass filter. In addition, the 15,750-Hz square waves are tapped out of the limiters through an emitter follower to provide horizontal drive for the camera.

Armature current is controlled by the switching circuit shown in Fig. 4. This system converts the varying amplitude signal at the output of the filter to a varying pulse-width armature current. Fig. 5-a shows the output signal at the low-pass filter: Fig. 5-b's waveform shows the increase in amplitude that results from "thumbing" the motor shaft. The signal is sinusoidal because almost all harmonics are removed by the low-pass filter.

A diode clamp ties down the negative peaks of the waveform to about 0.6 volt, and the positive excursions drive Q210 into conduction. The duration of the conducting pulse (conduction angle) depends upon the amplitude of the input signal. When Q210 saturates, Q211 is cut off. This leaves Q212 with a 470-ohm base resistor to B+, so Q212 saturates. Thus, Q212 follows the action of Q210.

Fig. 5-c shows the waveform at the collector of Q210. The negative-going part of the waveform represents the time that Q210 is saturated and thus represents the duration of the armature current pulse. Note the effect on the width of this pulse as the motor shaft is "thumbed" (Fig. 5-d). Diodes D209–D211 absorb energy produced by the motor when it is slowing down and acting like a generator. Starting capacitor C220 charges into the base circuit of Q210 when power is first applied. This gives the motor its starting kick.

Shibaden SV-707J portable

The servo in the Shibaden portable uses a monostable multivibrator with a rigidly controlled pulse width as the frequency reference. The system is shown simplified in Fig. 6. Transistors Q201 and Q202 form a monostable multivibrator in which Q202 is normally conducting and Q201 is cut off. This puts the collector of Q201 at about the B+ level.

A pulse from the amplified output of the tone generator turns off Q202 and this turns on Q201. This condition is maintained until the discharge of C203 through R-201 brings Q202's base voltage up to about 0.6 volt, at which time Q202 resumes conduction. Notice that R201 is not returned to B+ as in conventional multivibrators, but is returned to a steady reference voltage maintained by Zener diode D202. Pulse width is held within narrow limits.

At low speeds the collector of Q201 remains at B+ for relatively long periods, and drops to zero for the fixed conducting interval, as the top waveform in Fig. 6 shows. This waveform is filtered by an RC network and applied through a diode to one side of differential amplifier Q204–Q203.

Because the low-speed waveform is positive most of the time, the dc voltage applied to Q204 is highly positive and drives Q204 heavily into conduction. As a result of differential-amplifier action the heavy current through Q204 starves Q203 and the latter's collector voltage rises. Two cascaded emitter followers apply Q203's collector voltage to the motor armature and the motor is made to accelerate.

As motor acceleration continues, multivibrator Q201 and Q202 operates at higher frequencies and the duty cycle of the waveform at the collector of Q201 changes as shown. The result of filtering this waveform is a lower dc voltage. Thus, less current is applied to the motor armature. A stable operating point is reached where the output voltage of the filter is about equal to the dc voltage applied to the Q203-half of the differential amplifier. Note, too, that this base voltage is developed from Zener diode D202.

Speed is adjusted by varying the pulse width of the monostable multivibrator with R201. It is adjusted to obtain a motor speed of 30 rps with tape loaded and correct nominal battery voltage. It's quite easy to check speed. A scope is used to monitor the 60-Hz sync pulse developed by the set of pickup coils mounted on the scanner assembly, and the scope time base is synchronized by the power line. R201 is then adjusted until the pulses are stationary on the time base.

Control-track recording

All vtr's record a series of control-track pulses on the tape. They serve the same function as sprocket holes in movie film. During record, a control pulse is recorded on the tape each time one of the rotating video heads starts its

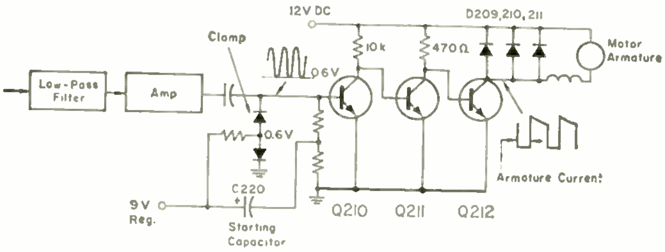


FIG. 4—THREE-STAGE SWITCH controls armature current.

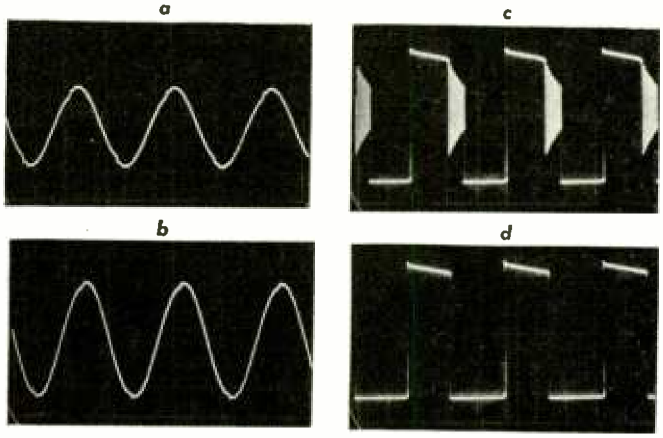
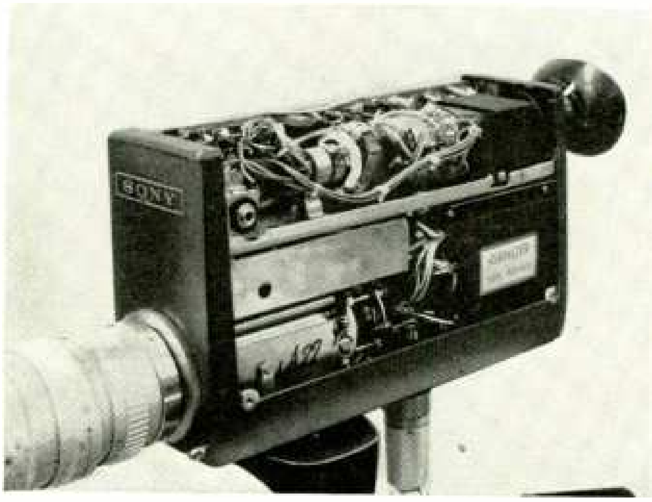


FIG. 5-a—LOW-PASS FILTER OUTPUT. b—Same output is boosted when motor is restrained. c—Waveform at collector of Q210 in Fig. 4. d—"Thumbed" motor widens the pulse width.



INSIDE SONY DVC-2400 camera showing CRT and magnet.

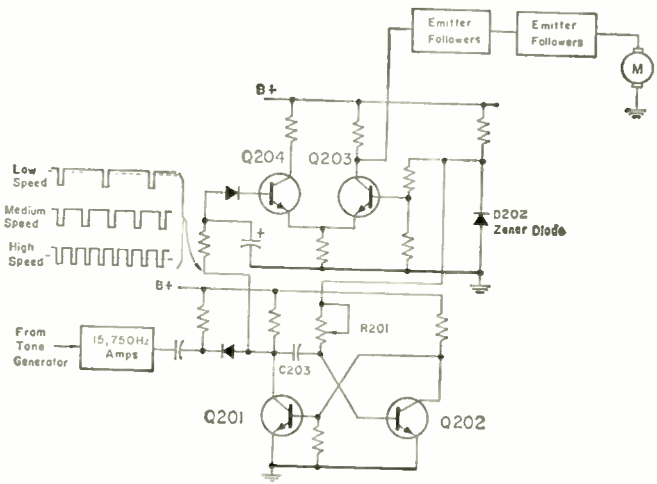


FIG. 6—SERVO CIRCUIT in the Shibaden vtr uses monostable multivibrator's pulse width as the frequency reference.

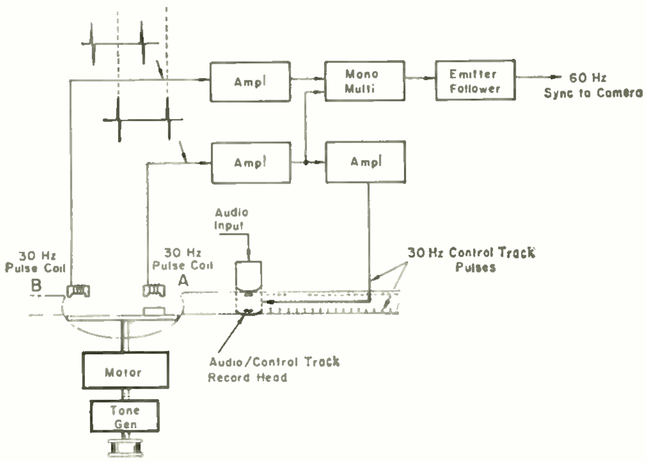


FIG. 7—CONTROL-TRACK PULSES are recorded on lower tape edge in DV-2400 every time the tape head starts its pass.

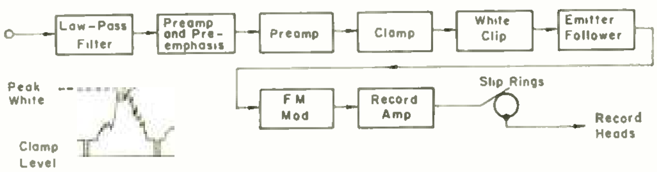
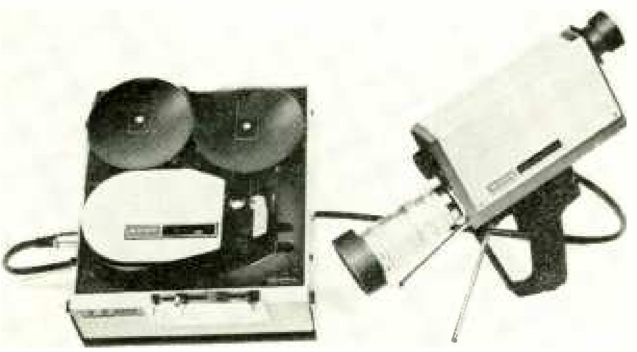


FIG. 8—VIDEO PROCESSING CIRCUITS in typical vtr. White-clip diode (waveform) prevents overloading of modulator.



TRIPOD ARRANGEMENT in Sony's vtr camera (above) provides stable base for some shots. Panasonic's NV-3080 (left) weighs only 21 pounds with its camera and batteries, and uses ½-inch tape.

CONCORD's VTR-400 (inside case) uses ½-inch tape running at 12 ips. It has two rotary heads on both record and playback, and has 14-min recording time.

swipe across the tape. (In playback, these pulses serve to tell the scanner's servo system that the recorded video track is in the correct position for the video head to start its pass across the tape.)

In vtr's with two video heads, a pulse is recorded once per revolution, at the start of the pass made by one of the video heads (usually designated the A head). The scheme used in Sony's DV-2400 is shown in Fig. 7. Here a set of pulse coils, 180° apart, is mounted above the rotating platform that mounts above the video-head assembly. A small iron vane is fastened to the beam on which the A video head is mounted. As the head sweeps around into position to begin its pass across the tape, the vane cuts the field of the pulse coil and a pulse (a single sine wave) is generated in the coil.

This pulse is shaped, amplified and applied to the control-track head. Here the pulse is recorded on the lower edge of the tape. (This audio-record head is mounted in the same assembly with the control-track head; audio is recorded on the top edge of the tape.) The same pulse used for control-track recording is also applied to a monostable multivibrator. This multivibrator is also triggered by the output of the second pulse coil shown in Fig. 7. Thus the multivibrator is triggered twice per revolution of the scanner to generate the 60-Hz pulses that serve as sync for the camera.

Video processing

In those machines that provide record-only operation, the video processing circuits are quite simple. Fig. 8 is the basic block diagram. Input video is amplified to provide the level of signal needed to drive the modulator. A low-pass filter usually precedes the video preamp to take out those high video frequencies that are not normally passed by the system and to prevent beats that might result from excessive FM deviation. Pre-emphasis, to improve the signal-to-noise ratio (just as in broadcast FM), is also accomplished in the preamp.

Following the preamp is a clamp to tie down the tips of sync to a set dc level. This level determines the sync-tip frequency at which the FM modulator operates. An emitter follower direct-couples the clamped signal to the modulator. The modulator is an astable multivibrator whose base-return connects to the output of the emitter follower. A positive-going (white) signal raises the base voltage, which brings the cut-off transistor back into conduction.

In other words, a positive-going video signal increases the repetition rate of the multivibrator. In Sony's DV-2400 the sync-tip frequency is 1.9 MHz and the video level is adjusted so that the peak-white part of the signal pushes the modulator up to 3.2 MHz. A white-clip diode shears off signals that might push the modulator past the maximum deviation value. (White compression is much less noticeable in the picture than overmodulation noise.)

The multivibrator is special in one regard: great pains are taken to insure strict waveform symmetry. This is required so that the carrier (1.9 MHz) can be removed completely by frequency doubling in the detector (during playback). Unless the FM signal is really symmetrical, residual carrier survives the filter that follows the FM detector and appears in the picture just like ordinary FM interference.

Following the FM modulator, a power amplifier drives the video recording head. Since the recorded signal is an FM square wave, saturation recording is used: record current is adjusted to drive the tape into saturation on both polarities of signal swing.

Cameras

The cameras used with portable vtr's require special design since they must operate from 12 volts dc, serve the

(continued on page 62)

CALMS TAPE TENSION.

Headache? Take aspirin.

Tape tension trouble? Take TEAC.

For instance, take the A-6010U stereo tape deck here – with its unique tape tension control system: an inertial flywheel and compliance arm for precision record/playback running speeds and smooth, fast winding. This system helps reduce external factors contributing to wow and flutter, such as warped reels and splices.

TEAC offers fast relief for other common complaints, too: unique ***phase sensing auto reverse*** operates electronically at any chosen point on the tape, or takes a sensing foil if you'd rather. Separate heads permit ***source- or off-the-tape monitoring while recording*** for easy A/B comparisons. And our exclusive ***symmetrical control system*** makes tape handling logical and easy – fast or slow, forward or back, at a flick of the finger.

This tape deck can't cure everything that ails you, but you're bound to feel better once you own one.

TEAC

TEAC Corporation of America • 2000 Colorado Avenue • Santa Monica, California 90404

Correspondence

TUNE-UP TIPS

In the April issue the article, "Tune Up Your Car With a VOM," was very interesting. However, there are two points worth noting:

(1) When setting the timing on a four-cycle engine, make certain that the distributor rotor is pointing to the contact for the one cylinder, since the timing mark on the flywheel or harmonic balancer is at its timing position for two different positions of the distributor rotor.

(2) An unmodified VOM can be used to measure the "dwell" by measuring the voltage from the ignition switch terminal of the ignition coil to ground when the engine is running, and comparing this measurement with a measurement when the engine is stopped with the points closed. The same type of calculation as set forth in the article would be used to determine the "dwell." This method is actually measuring the voltage drop across the ignition resistor, which is not shown in the article.

DANIEL E. SRAGOW
74 Westerloe Avenue
Rochester, N. Y. 14620

JAPANESE ENGLISH

Surely a problem for all technicians who have ever had the occasion to perform repair work on foreign equipment is the deciphering of the instruction manual from the manufacturer.

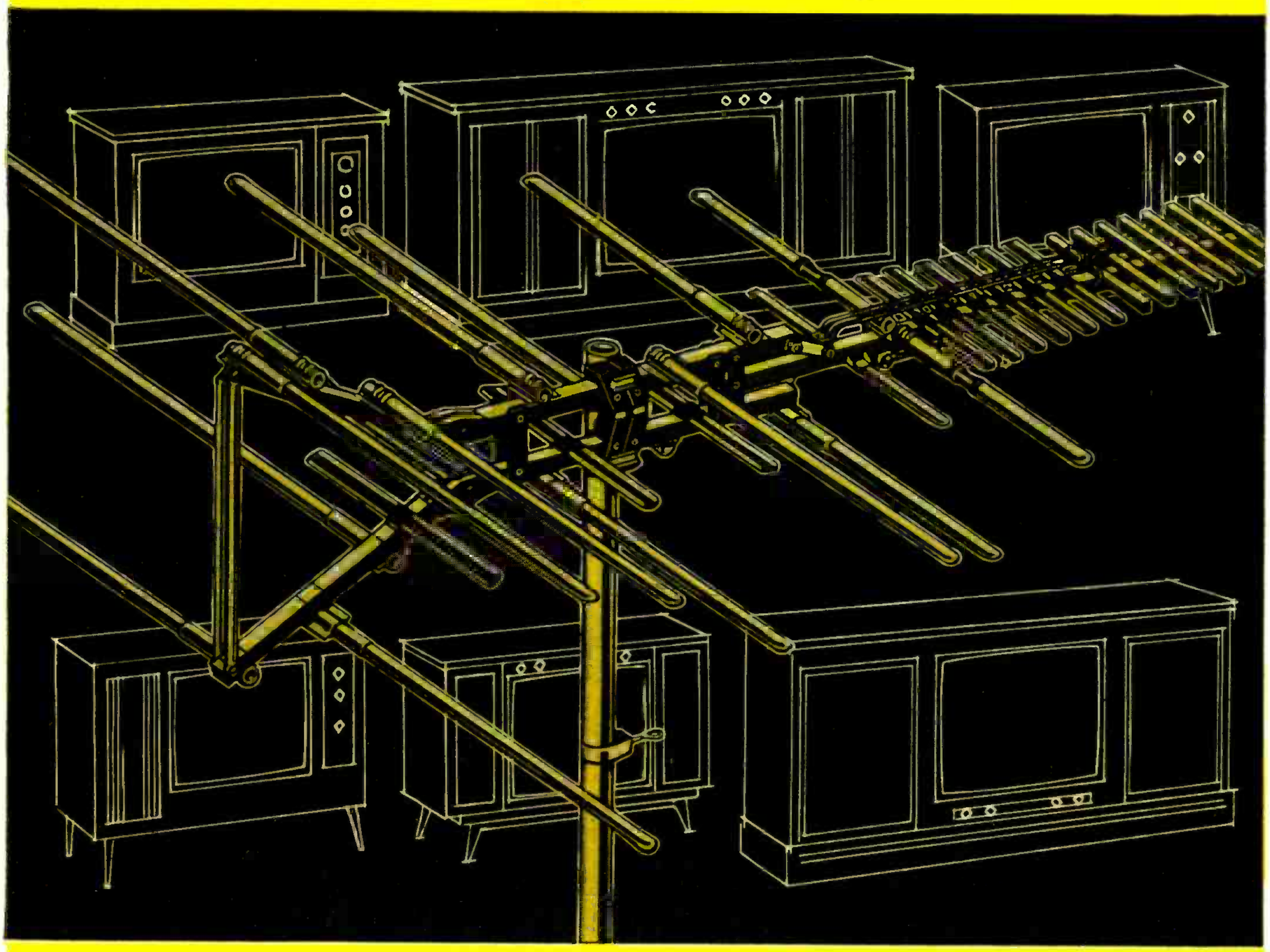
My company recently purchased several Japanese facsimile units and placed them into operation. Our first case of trouble on one of these units occurred this past month and sent me running for the tech manual that came with the units for help.

Having fully concluded that something in this manual was lost through translation, I thought you would enjoy hearing a couple of quotes from this manual.

"Generally speaking, the transistors operated with high voltage tend to be broken."

"(If such transistor trouble should be caused, a short circuiting phenomenon will develop between the emitter and collector very often.)"

(continued on page 20)



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CORRESPONDENCE

(continued from page 14)

"Check the existence of voltage or power. If there exist no voltage . . ."

Well, on the case of trouble that I had, I decided to check and see what was to be said in the section "Electrical Trouble Shooting" which I discovered in the table of contents. Lo and behold it sure had plenty to say. I'm not too sure what it is, but it must explain my problem:

"The electrical troubles which might be caused in the respective electronic circuits adopted in this equipment may be corrected corresponding to the general electronic equipment."

David L. Downing
4432 Pommore Drive
Milford, Mich. 48042

CAREER IN AVIONICS

The article by Len Buckwalter on careers in aviation electronics was interesting. I'd like to know if a service technician would have any difficulty entering the avionics field.

John Mason
New York City

Any qualified service technician who knows how to troubleshoot color TV or stereo should easily make the transition into avionics. Many of the signals are similar, though put to unfamiliar use.

Take signal phase, for example, which encodes hue information in a color TV receiver. In an aircraft receiver, signal phase constructs a magnetic heading in compass degrees from a navigational ground station.

Another similarity is in pulses; in a TV receiver they provide picture sync and blanking—in an aircraft they provide radar and the DME function described. So there's considerable overlap between the two fields.

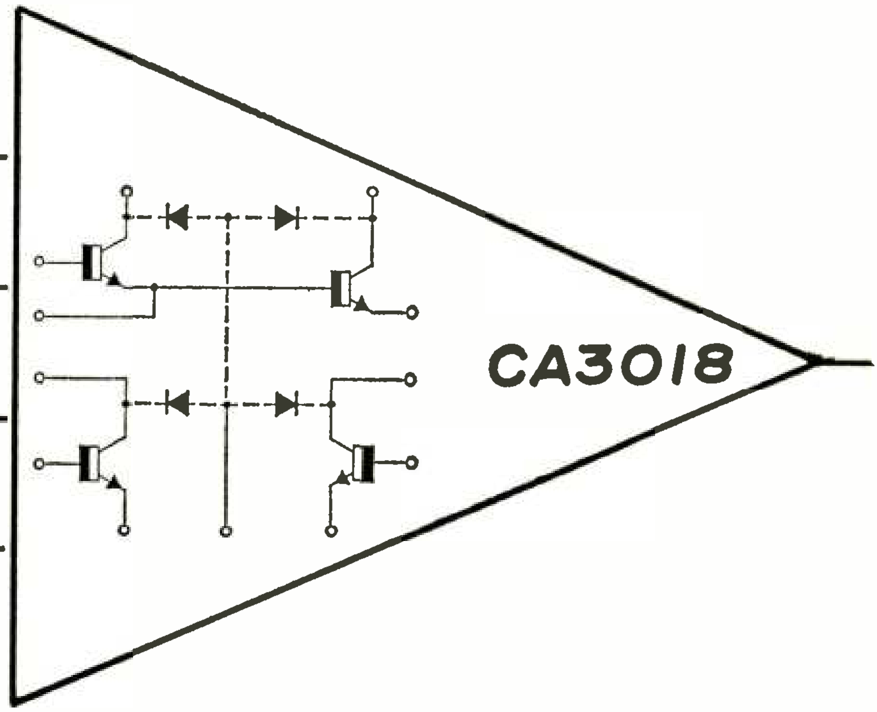
One avionics shop-owner believes the toughest part of the transition is simply learning how to operate aviation electronics gear. Before tackling a VOR receiver, for example, the man must know the meaning of the dial marked "OBS" (Omnibearing Selector) or that "CDI" is "Course Deviation Indicator". On the transmitting end, the equipment is mainly VHF-AM, and an FCC commercial ticket is good evidence of proficiency in this area.

Len Buckwalter
Georgetown, Conn.

COMING NEXT MONTH

TV set owners today want clean reception for quality pictures. Learn how to select antennas and lead-in.

30 new IC circuits you can use



by **R.M. MARSTON**

Versatile four-transistor IC operates from dc to vhf. Build basic amplifiers, hi-fi stereo preamps, icing and temperature indicators, light-operated switches, electronic locks, meter amplifiers, Schmitt triggers and more

ONE OF THE SIMPLEST YET MOST VERSATILE integrated circuits yet devised is the CA3018 by RCA. Its manufacturer describes this modestly priced (under $2) unit, which is housed in a 12-lead TO-5 sized case, as an "Integrated-Circuit Transistor Array."

The device houses four independently accessible silicon transistors in the single package. The package offers a theoretical total current gain of roughly 25 million times.

The four transistors in the package are not "ordinary" transistors. They are vhf types, with typical f_T (gain/bandwidth product) figures of 400 MHz, and are tested to military standards. They can be operated over a −55°C to +125°C temperature range. Most important of all, they are all etched on the same slice of silicon, and thus have very closely matched characteristics, and operate at the same substrate temperature.

These features enable this IC to out-perform normal transistors in most circuits. In some instances use of the CA3018 permits devising circuits to do jobs that would be economically impossible using normal transistors.

An outstandingly versatile IC, the CA3018 can be used in hundreds of interesting applications. In this article, we will show you 30 of the many practical projects you can build around it.

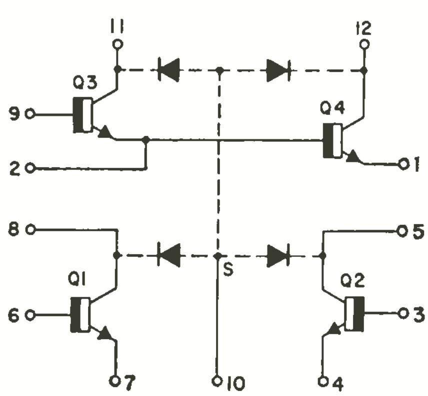
The internal circuit and pin connections of the CA3018 are in Fig 1. The IC houses four silicon transistors. Transistors Q1 and Q2 are electrically isolated and can be used independently.

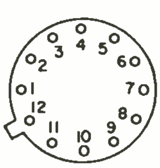
Transistors Q3 and Q4, on the other hand, share a common base-to-emitter terminal, so these units are connected basically as a Darlington or Super-Alpha pair. Each transistor of the connected pair is, however, independently accessible. A diode (shown dotted) is effectively connected between the collector of each transistor and the substrate (pin 10) of the IC. These diodes occur as an incidental part of the IC manufacturing technique, and have no effect on circuit operation in most applications. The substrate (pin 10) is internally connected to the metal case of the IC, and should be grounded in most applications.

Since all our transistors in the CA3018 are etched on a single slab of silicon, their characteristics are inevitably very closely matched to one another, even though the characteristics of individual IC's may vary over fairly broad limits. Also, all four transistors inevitably operate at almost identical temperatures, so their characteristics remain closely matched over a very wide temperature range. Transistors Q1 and Q2 have a near-perfect h_{FE} (dc current gain) match over the temperature range −55°C to +125°C.

The general characteristics of the

INTERNAL CIRCUIT OF THE CA3018
NOTE: S = SUBSTRATE





PIN CONNECTIONS OF THE CA3018
NOTE: PIN 10 INTERNALLY CONNECTED TO CASE.

Characteristics of the CA3018

V_{CEO} (max) [each transistor]	15V
V_{CBO} (max) [each transistor]	20V
V_{EBO} (max) [each transistor]	4V
Max collector-to-substrate voltage [each transistor]	20V
I_C (max) [each transistor]	50 mA
I_{CBO} @ 25° [each transistor]	0.1 µA (max)
f_T [each transistor, substrate grounded]	400 MHz (typ)
h_{FE} @ 1mA [each transistor]	67 (typ), 30 (min)
h_{FE} @ 1mA [Q3-Q4 pair]	3500 (typ), 1500 (min)
Q1-Q2 input-offset voltage @ $I_{C1} = I_{C2} =$ 1mA	1mV (typ), 5mV (max)
Q1-Q2 temperature coefficient of input-offset voltage @ $I_{C1} = I_{C2} =$ 1mA	10µV/°C (typ)
P_T (max) [each transistor]	300 mW
P_{TOT} (max) [total package]	300 mW

FIG. 1—TRANSISTORS Q1 AND Q2 are electrically isolated, although the common substrate gives them an excellent h_{FE} over a wide temperature range. Transistors in Q3–Q4 pair may be operated independently.

CA3018 are tabulated in Fig. 1. Note that all transistors have a typical f_T (with pin 10 grounded) of 400 MHz, so the IC can be used in applications ranging from dc to vhf. Also note that the Q3–Q4 pair has a typical h_{FE} of 3500 at a collector current of 1 mA, so the IC can be used in high-current-gain and high-input-impedance applications.

Finally, note that Q1 and Q2 have their forward base-to-emitter voltages matched to a typical value of 1 mV, with a typical temperature coefficient of only 10 μV/°C (compared to 2 mV/°C of a single conventional transistor), so the IC is outstandingly well suited to high-performance dc differential amplifier applications.

Basic connections of the unit

The CA3018 is fairly easy to use, since it can be regarded simply as a block housing a number of normal (more or less) and independent transistors. Transistors Q1 and Q2 can be regarded as totally independent and can be used either individually or simultaneously, without restriction. Similarly, each of the Q3–Q4 pair is independently accessible, so either of these devices can be used as an independent transistor, so long as the other member of the pair is left unused.

For example, Fig. 2 shows how to connect the IC as a simple common-emitter amplifier, using Q4 only. Here, R1 acts as a collector load, and R2 as a bias resistor that sets the quiescent collector potential at roughly half the supply voltage. The bias currents are subject to negative feedback, so good stability is obtained from this simple arrangement.

The circuit can be operated from any dc supply in the range 3 to 15 volts. Using a 9-volt supply, the design gives a voltage gain of about 43 dB, has an input resistance of 1500 ohms and an output resistance of 6800 ohms. The frequency response of the circuit extends from 30 Hz to several hundred kHz.

Similarly, Fig. 3 shows how the IC can be used as a simple emitter follower, using Q4 only. Here, R1 is used as the emitter load, and R2 is the bias resistor, again operating in the negative feedback mode. The circuit can be used with any 3-to 15-volt dc power supply. Using a 9-volt supply, the circuit has an input resistance of 220,000 ohms, unity voltage gain and a frequency response that extends from 30 Hz to several hundred kHz.

Note in both Fig. 2 and Fig. 3 that Q3's emitter is connected to Q4's base and does not restrict the use of Q4 as an independent transistor, so long as Q3 is left unused. The IC can thus be used simply as a block housing three independent transistors (with Q3 unused), if required.

Such an approach would, of course, be rather wasteful of circuit potential, since both transistors in the Q3–Q4 pair can be used simultaneously in a number of ways. One way of doing this is to ground pin 2 of the IC and then use Q3 as a common-emitter amplifier (with input to pin 9) and Q4 as a common-base amplifier (with input to pin 1).

Alternatively, Q3 can be used as an emitter follower, with its output feeding directly into the base of common-emitter amplifier Q4. A number of other basic ways of using the Q3–Q4 pair are shown in Figs. 4 through 7.

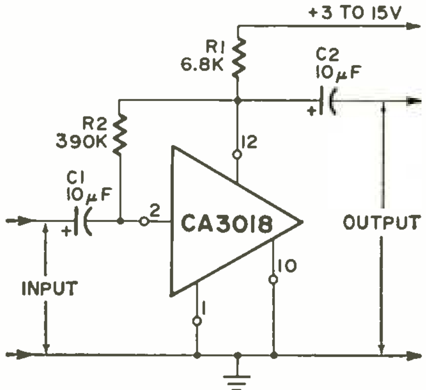
Fig. 4 shows how to connect the IC so Q4 is used as a simple common-emitter amplifier with built-in protection against damage by excessive input signals. Here, the base–emitter junction of Q3 is used as a reverse-biased silicon diode between Q4 base and ground.

If excessively large input signals are connected to the circuit, this diode becomes forward-biased on the negative-going parts of the signal, and insures that the emitter-to-base ratings of Q4 are not exceeded. With normal signal inputs, the diode is inoperative and the performance of the amplifier is identical to that of Fig. 2.

Fig. 5 shows how Q3–Q4 can be connected as a Super-Alpha pair for use as a common-emitter amplifier with a high input resistance. This particular circuit can be used with any supply in the 4.5- to 15-volt range.

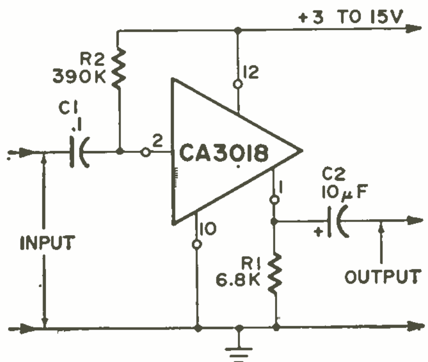
Using a 9-volt supply, it delivers 40 dB voltage gain, has an input resistance of 82,000 ohms, an output resistance of 6800 ohms, and a frequency response within 3 dB from 30 Hz to about 250 kHz.

Fig. 6 shows how the Q3–Q4 pair



USING A 9-V SUPPLY
A_V = 43dB
R_{IN} = 1.5K
R_{OUT} = 6.8K
F_R = 30Hz - 700KHz ±3dB

FIG. 2—COMMON-EMITTER AMPLIFIER connections for using only Q4 in the Darlington pair. The IC will operate over a wide dc supply range, providing a 43 dB gain with 9 volts.



USING A 9-V SUPPLY:
R_{IN} = 220K
F_R = 30Hz - 700KHz ±3dB

FIG. 3—EMITTER-FOLLOWER circuit using only Q4 offers a voltage gain of unity.

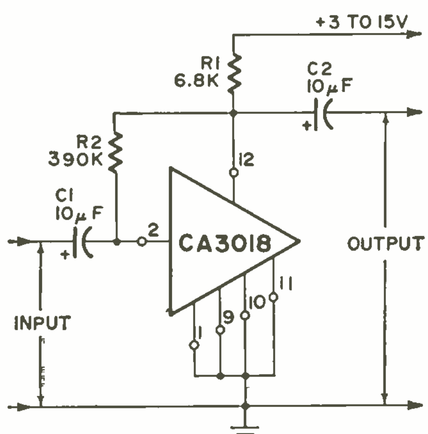
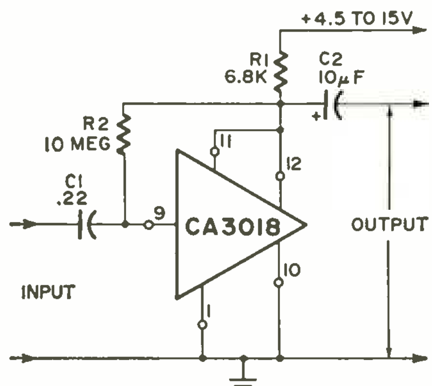


FIG. 4—PROTECTED COMMON-EMITTER amplifier uses Q3 as diode to limit signal to Q4.



USING A 9-V SUPPLY:
A_V = 40dB
R_{IN} = 82K
R_{OUT} = 6.8K
F_R = 30Hz - 250KHz ±3dB

FIG. 5—SUPER-ALPHA PAIR Q3–Q4 used as 40-dB gain common-emitter amplifier.

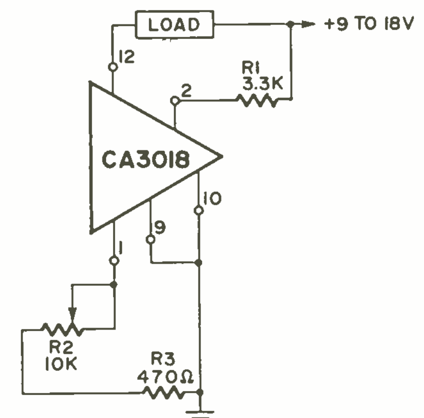
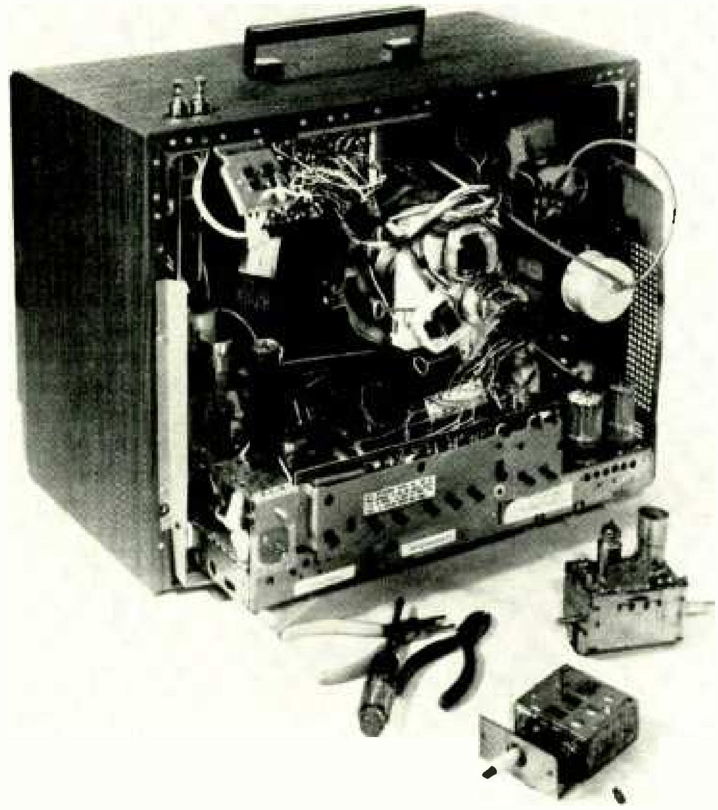


FIG. 6—CONSTANT-CURRENT GENERATOR uses Q3 like Zener diode. Q4 is current source.



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can be used as a constant-current generator. Here, the base–emitter junction of Q3 is heavily reverse-biased from the 9- to 18-volt positive supply line via R1. The reverse base–emitter breakdown voltages of the transistors in the CA3018 are very sharply defined at about 6.5 volts, so Q3 acts as an excellent Zener diode, and applies a fixed potential of roughly 6.5 volts to Q4's base almost irrespective of the actual supply-line voltage. Transistor Q4 is wired as an emitter follower, with an external load connected in series with its collector, and with resistors R2 and R3 wired between its emitter and ground.

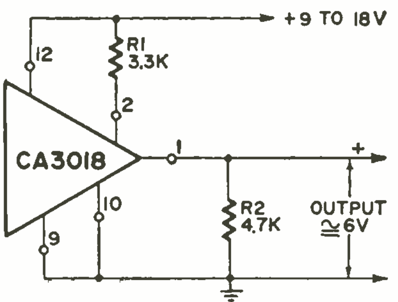


FIG. 7—CONSTANT-VOLTAGE SOURCE uses Q3–Q4, applying Q3's Zener voltage to Q4.

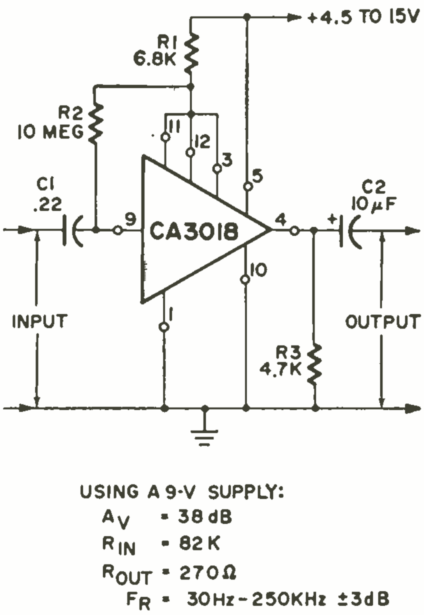


FIG. 8—COMMON-EMITTER AMPLIFIER has high input and low output resistance.

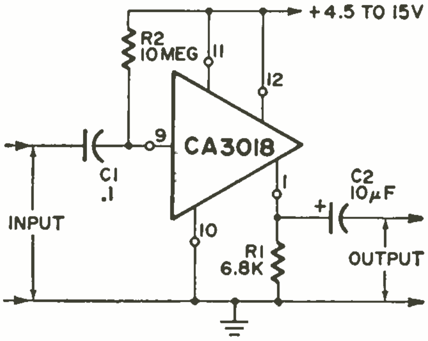


FIG. 9—CERAMIC-CARTRIDGE amplifier has 5-megohm input resistance using Q3, Q4 and Q2.

The collector current of Q4 is dictated almost entirely by the value of Zener voltage on Q4's base and by the values of R2 and R3. It is substantially independent of the value of collector load resistance and supply-line voltage (so long as Q4 does not run into saturation). Therefore, Q4's collector (pin 12) acts as a constant current source.

The circuit can be used with any supply in the 9- to 18-volt range. With an 18-volt supply, the constant-current magnitude can be set (via R2) at any value between 0.4 mA and 14 mA.

Finally, Fig. 7 shows how the Q3–Q4 pair can be used as a constant-voltage source. Here, Q3 is again used as a Zener diode, with its Zener voltage fed directly to the base of Q4. And Q4 is wired as an emitter follower.

In this circuit, however, Q4's collector is taken directly to the positive supply line, and the output of the circuit is taken from Q4's emitter.

Due to the emitter-follower action of Q4, the potential at the output of the circuit remains virtually constant at about 6 volts (Zener voltage minus the

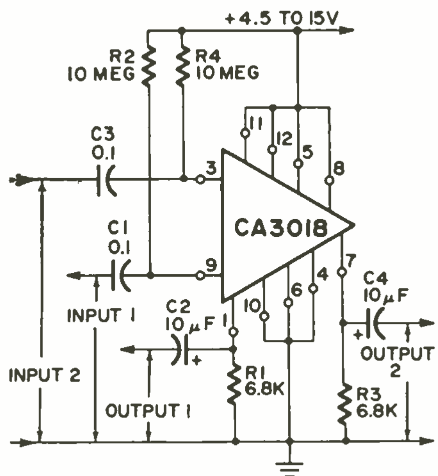


FIG. 10—STEREO EMITTER-FOLLOWER circuit like Fig. 9, using all four transistors.

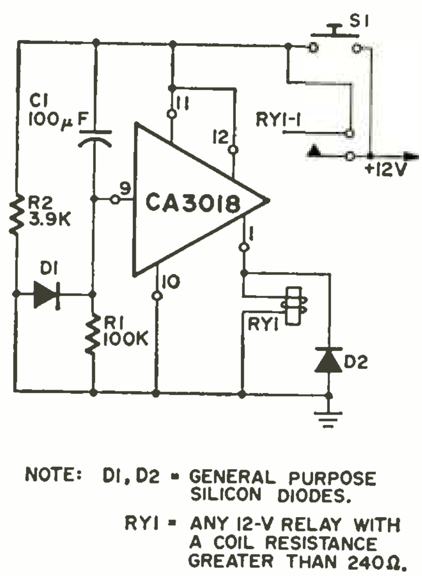


FIG. 11—RELAY DRIVER operates RY1 from Q3–Q4 pair, deenergizing relay after 12 sec.

forward base–emitter voltage drop of Q4) over the supply-line range of 9 to 18 volts and over the output-current range 0 to 20 mA. The circuit acts as a constant-voltage source.

High-input-impedance amplifier

It has already been mentioned that, because of the high available current gain of the CA3018, the IC is suitable for use in a variety of high-input-impedance applications. In this section, we will look at three amplifier projects that use these high-impedance techniques.

We have already seen, in Fig. 5, how the Q3–Q4 pair can be used as a common-emitter amplifier with a high input resistance. One snag with this particular circuit, however, is that it has the moderately high output resistance of 6800 ohms. Consequently, appreciable resistive or capacitive loading of the output inevitably causes a substantial loss in either voltage gain or upper frequency response of the circuit. This can be overcome by using the connections shown in Fig. 8.

Here, Q3 and Q4 are again used as a Super-Alpha pair and are connected in the common-emitter mode. But this time an extra transistor, Q2, is wired as a direct-coupled emitter follower between the Q3–Q4 collector load and the circuit output at pin 4.

The complete circuit thus has a high input and low output resistance, and its gain and frequency response are not greatly influenced by output loading conditions. The circuit can be used with any supply between 4.5 and 15 volts. When used with a 9-volt supply, it delivers a voltage gain of 38 dB, has an input resistance of 82,000 ohms, an output resistance of 270 ohms and a frequency response within 3 dB from 30 Hz to 250 kHz.

When very high input impedances are required, the IC can be used as a Super-Alpha connected emitter-follower mode (see Fig. 9). Transistors Q3 and Q4 are used as the Super-Alpha pair.

The circuit works with any supply from 4.5 to 15 volts, and has an input resistance of about 5 megohms. The frequency response of the circuit extends from less than 10 Hz to several MHz. The circuit works as a high-performance preamp for crystal or ceramic pickups.

Finally, Fig. 10 shows a stereo version of the Super-Alpha emitter follower. Two complete circuits, each identical to Fig. 9, are built from one IC. One circuit is built around Q3 and Q4, and the other around Q1 and Q2.

Since all four transistors in the CA3018 are closely matched, the two circuits give virtually identical performances. This project is thus perfectly suited for use as a hi-fi stereo preamp for crystal or ceramic pickups.

Relay-driving projects

The CA3018 can be used in a number of interesting relay-driving applications. For example, Fig. 11 shows how to connect the IC so it instantly triggers a relay when pushbutton switch S1 is momentarily operated, and turns the relay off again automatically after a fixed

delay of about 12 sec. Longer delay periods can be obtained by increasing the value of C1.

Circuit operation is simple. Transistors Q3 and Q4 are wired as a Super-Alpha emitter follower, with the relay as the emitter load, and the input of the emitter follower (pin 9) is taken to the junction of R1 and C1.

Circuit operation is initiated by momentarily closing S1. At the instant that S1 is closed, C1 is fully discharged, so pin 9 is effectively shorted to the positive supply source at this time, and the relay is driven on by emitter-follower action. As the relay goes on, contacts RY1-1 close and keep the supply voltage connected to the circuit when S1 is then released.

As soon as the supply is connected to the circuit via S1, C1 starts to charge exponentially via R1. As it does, the voltages at pins 9 and 1 fall slowly toward zero. After about 12 sec, the voltage at pin 1 falls to such a low value that the relay turns off. As the relay turns off, contacts RY1-1 open and break the supply to the circuit. Then C1 discharges rapidly via D1 and R2. The circuit is then ready for the next operation of S1.

The circuit shown above is designed around Q3 and Q4 only. It can be used equally well with Q1 and Q2. Thus, two complete circuits of this type can be made from a single IC. In the circuit, D2 ensures that the IC is not damaged by back emf from the relay coil as the relay switches on or off. The relay can be any 12-volt type that draws an operating current of less than 50 mA—one that has a coil resistance greater than about 240 ohms.

The time delay of the Fig. 11 circuit is controlled primarily by the time constant of R1 and C1. The larger the value of either of these components, the longer the available time delay. In practice, however, the maximum usable value of R1 is restricted to about 100,000 ohms. If larger R1 values are used, the high leakage currents of electrolytic capacitor C1 may generate such a large voltage on pin 9 that the relay is unable to turn off. Fig. 12 shows a circuit that overcomes this snag, and gives a turn-off delay of about 2 min. from a standard 100-μF electrolytic capacitor.

This circuit uses only Q2 and Q4. Transistor Q2 is wired as a common-emitter amplifier, with the relay coil as its collector load. Transistor Q4 is wired as an emitter follower, with its emitter current feeding into Q2's base via limiting resistor R2, and with its own base (pin 2) connected to the junction of C1 and R1. Resistor R1 is the main time-constant unit, and is wired between Q4's base and ground via Q4's emitter and R2 and R3.

Circuit action is initiated by briefly closing S1. At the instant S1 first closes, C1 is fully discharged. Pin 2 is effectively shorted to the positive supply line at this moment, and Q2 and the relay are driven on by the emitter follower action of Q4. As the relay is energized its contact closes, keeping the supply line connected to the circuit when S1 is released. As soon as the supply is connected to the circuit via S1, C1 starts to charge exponentially via R1. As C1 charges, the voltage at pin 2 and the current into Q2's base start to fall slowly toward zero. Consequently, after a delay of about 2 min, Q2's base current falls to such a low value that Q2 turns off and the relay is de-energized. The contacts open, breaking the supply to the circuit. C1 then discharges rapidly via D1 and R4. The circuit is then ready for the next operation of S1.

The important point to note about this circuit is that R1 is not connected directly between Q4's base and ground. Instead it is wired between Q4's base and emitter and then to ground via R2 and R3.

Due to the emitter-follower action of Q4, the voltage across R1 is constant at about 0.65 volt, and changes of voltage on pin 2 cause only negligible changes in R1's current. R1 is thus "bootstrapped" and appears, to *varying* pin 2 signals, as an impedance of several megohms.

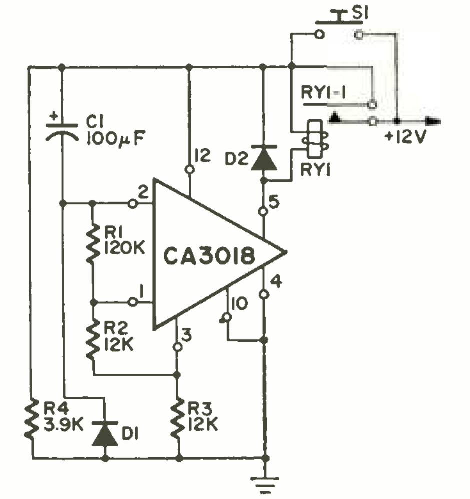
To steady dc signals, on the other hand, R1 appears as a simple resistance of only 120,000 ohms. Thus, R1 appears as a very high resistance to the exponentially varying charging currents of C1, but appears as a moderately low resistance to steady C1 leakage currents. The circuit, therefore, generates very long time delays without problems from C1 leakage currents.

Another way of connecting the IC as a relay-driving time-delay circuit is in Fig. 13. Here the circuit does not turn the relay on until about 12 sec after S1 is closed. The circuit is similar to Fig. 11, with Q3 and Q4 connected as a Super-Alpha emitter follower that uses the relay as its emitter load, and with pin 9 connected to the C1–R1 junction. This time, the positions of C1 and R1 are reversed in the circuit.

When S1 is first closed, C1 is fully discharged, so pin 9 is effectively shorted to ground. Due to the emitter-follower action of Q3 and Q4, pin 1 is also held at ground potential, and the relay is held off at this stage.

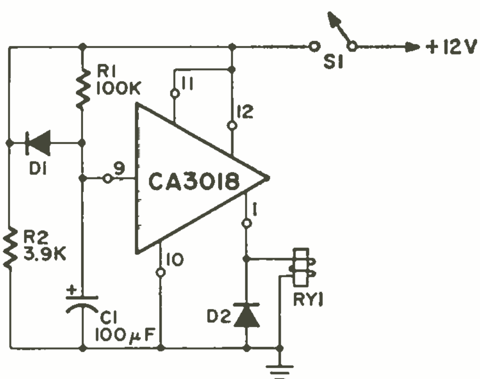
As soon as S1 is closed, C1 starts to charge exponentially via R1. As it charges, the potentials on pins 9 and 1 start to rise slowly toward the positive supply. After a delay of about 12 sec, pin 1's voltage reaches such a high value that the relay turns on. The relay remains on until S1 is opened again. As soon as S1 is opened, C1 discharges rapidly via R2 and D1. The circuit is ready to operate again as soon as S1 is closed once more.

Fig. 14 shows how to connect the IC as a sensitive water-operated switch, with a relay output. Circuit theory is simple. Transistors Q3 and Q4 are connected as a Super-Alpha pair, wired in the common-emitter mode, with the relay as the collector load and with input applied to pin 9. This pin is connected to a metal probe via limiting resistor R2 and to ground via R1. A second metal probe is connected to the positive supply for the IC.



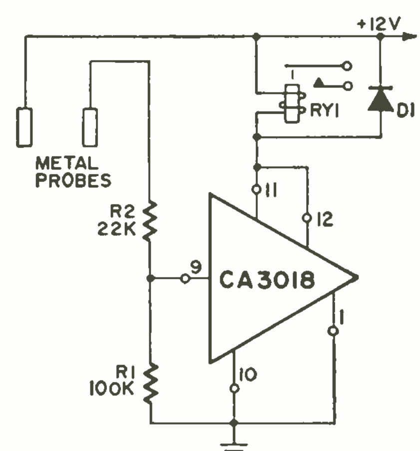
NOTE: D1, D2 = GENERAL PURPOSE SILICON DIODES.
RY1 = ANY 12-V RELAY WITH A COIL RESISTANCE GREATER THAN 240Ω.

FIG. 12—LONGER DELAY for relay is achieved in this circuit configuration for the IC.



NOTE: D1, D2 = GENERAL PURPOSE SILICON DIODES.
RY1 = ANY 12V RELAY WITH A COIL RESISTANCE GREATER THAN 240Ω.

FIG. 13—TIME-DELAY RELAY DRIVER energizes RY1 about 12 sec after S1 is closed.



NOTE: D1 = GENERAL PURPOSE SILICON DIODE.
RY1 = ANY 12-V RELAY WITH A COIL RESISTANCE GREATER THAN 240Ω.

FIG. 14—WATER-OPERATED SWITCH uses Q3–Q4 in common-emitter mode to turn RY1 on.

(continued on page 73)

Hobbyist-priced color TV cameras are only a few years off. Here's a look at new techniques that will make them possible

NEW COLOR TV CAMERAS

by **WALTER G. SALM**

'SCRAMBLER' made for ABC by Ampex uses field sequential scanning system.

THE MONOCHROME TV camera has become so firmly entrenched as a closed-circuit and experimenter's item that we no longer think of its presence as a curiosity. The reason: low-cost, made possible by production corner-cutting, second-quality Japanese vidicon pickups and the wide tolerance latitudes possible in "home" and low-cost commercial applications. A black-and-white vidicon camera can be had for as little as $200 today (in kit form from Conar) and somewhat more for transistorized ready-mades.

When it comes to color cameras, the story is vastly more complicated. A color camera is basically three cameras in one, with lots of extra circuits. It must first break the image down into its three TV primary colors of red, blue and green.

Three or four pickups?

This is done in three-pickup cameras through an optical system that generally consists of two semi-silvered mirrors, two filters (red and blue), two more mirrors or prisms and a series of field-correcting and compensating lenses.

The only pickup that gets a fairly simple shot at the image is the green, since this is also the luminance (Y) channel in three-pickup cameras. The Y channel brightness gets a straight-through shot from the camera's lens with no intervening filters. The green color signal is derived later by subtracting R and B from Y.

Optically and electronically, the three-pickup camera is vastly simpler than the four-pickup cameras that are now going out of vogue in the broadcast industry. These latter cameras sought to compensate for overall poor pickup-tube efficiency by having a separate image orthicon tube for the luminance channel and by providing a filtered green channel. This meant fewer electronic gymnastics but there was the added expense of a fourth imaging device and its associated backup circuitry.

Three-pickup cameras were tried in the very early days of NTSC color, but they provided a poor luminance signal. A fourth image-orthicon was added, and the four-pickup camera became the industry standard. Some broadcasters still feel the separate luminance tube provides the best possible signal compatibility.

Then along came the first successful commercial TV camera with three pickups—the Norelco PC-70. Until it was introduced at the 1966 National Association of Broadcasters Convention, four tubes was the chosen way. What really made this new camera possible was the development of the separate-mesh, lead-oxide vidicon tube by Norelco's parent company, N. V. Philips Gloeilampenfabrieken. Philips promptly dubbed this tube the Plumbicon—a trademark both ingenious and logical, being derived from the Greek root word *plumbos* for "lead."

The sheer magnitude of the Plumbicon's development is revealed by the fact that RCA and GE were both quietly using "lead-oxide mesh vidicons" (purchased from Philips) in their advanced color cameras in 1968 and '69. By the end of 1969, GE proudly announced it had developed its own lead-oxide mesh vidicon and planned to use it for broadcast TV cameras. The difficulty in setting up quality production of this tube is borne out by the fact that GE is still buying Plumbicons from Philips.

Color cameras settled into a fairly fixed-price mold for a couple of years. Any broadcaster, school system or private citizen who wanted one could go out and buy it for about $65,000 to $85,000—depending on options. Obviously, at such a price, color was out of the question for most schools, colleges, small TV stations, CATV operators doing local origination, and certainly the experimenter and TV ham.

But in 1967, things began to happen. One little-heralded but significant development came out of Japan. Nippon Columbia succeeded in producing color TV images using a *single vidicon* tube. N.C. engineers were able to produce a prototype camera that weighed substantially less than other color units and presumably, in production would also cost quite a bit less.

The camera was tested by NHK—the Japanese national TV network—but never got much beyond this point. It has never been publicly demonstrated, and Nippon Co-

PORTABLE CAMERA requires complex support gear.

lumbia is very tight-lipped about the final results. But the camera's underlying principles showed up later in a single-tube color camera by RCA and in two-tube cameras by Sony and Toshiba.

In the meantime, the ABC network decided to push for all-out sports coverage. To do this, a light, fully portable color camera was needed. So ABC contributed substantial funding to a crash research and development program at Ampex for such a camera. The result was the Ampex BC-100 (dubbed the "Scrambler") which in late 1967 easily gave ABC a scoop on the other networks.

It wasn't a cheap camera by any means, running about $100,000 each with the needed support equipment. The big news was not so much its portability, but how it was achieved. For the first time, a color camera had been made for regular broadcast use with just two pickup tubes.

As with all portable cameras that followed, the head itself was trimmed to the bone, with the needed electronics relegated to a backpack. This was done to keep the head weight down to reasonable proportions for mobility and ease of handling. But the cameraman wouldn't win any 100-yard sprints with that 30- or 40-pound backpack weighing him down.

The head itself was something of a throwback. It used (and still uses) a spinning filter disc to separate the red and blue color information into a field-sequential signal. A straight-through signal feeds the Y pickup tube. Both tubes are Plumbicons.

Getting that field-sequential information decoded and into standard NTSC form is no mean feat. Early versions of the camera relied on a videodisc recorder in the camera control unit (at the base station) to provide the needed one-line delay. Later models eliminated the videodisc in favor of a delay line.

The camera got an immediate baptism of fire—first at college football games, then in the subzero cold of Chamrousse while covering the 1968 Winter Olympics at Grenoble. ABC scored one coup after another with this camera, and used it again at the Summer Olympics that year in Mexico City.

In the meantime. RCA and CBS Labs weren't sitting on their duffs. They both developed portable cameras that used three pickup tubes and met all the requirements for light head weight and NTSC color output. These entries were hurried to completion for use on the floor at both 1968 presidential nominating conventions. Both the CBS and RCA cameras were engineering prototypes. We can only guess what the CBS Minicam cost, but we understand that the four cameras provided by RCA for NBC cost a cool million dollars each to produce!

The CBS Minicam has since been licensed to Philips, and is now in production with an approximate price tag of $100,000, in a wireless microwave version.

IVC sticks with vidicons

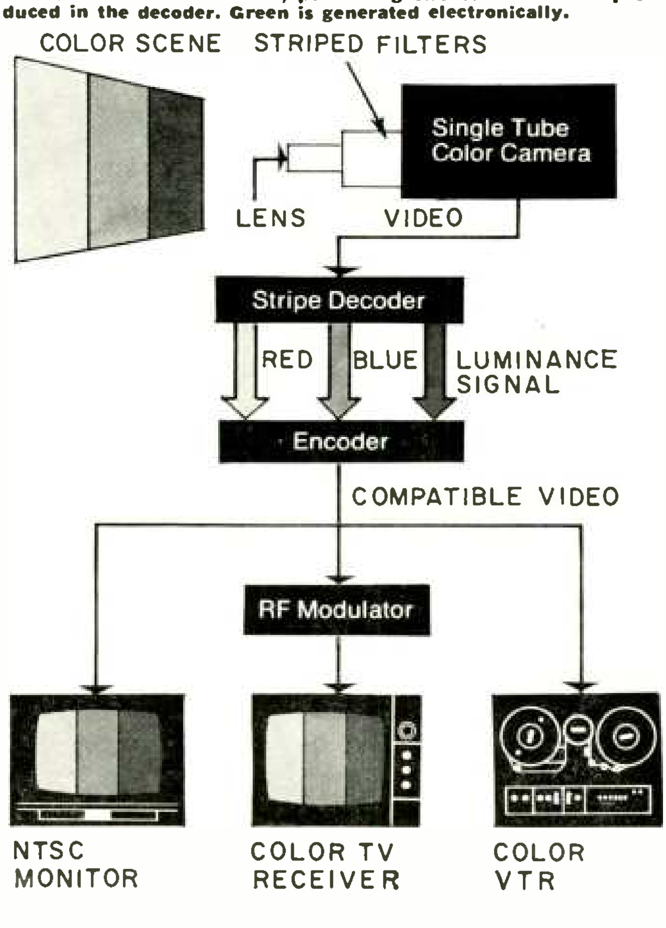
While all this was going on, a small group of engineers calling themselves International Video Corp.—mostly ex-Ampex people—had just completed work on the infant company's compact helical color video recorder. They decided to take a crack at color cameras while they were at it and came up with a three-vidicon unit that really did the job and could be sold for an unbelievable $14,500!

This was the IVC-100 (now discontinued) and the low cost was made possible by using vidicons instead of Plubicons, a fixed, nonadjustable, sealed optical system that could be mass-produced at low cost, and a head largely devoid of the many bells and whistles usually associated with color broadcast cameras.

To be sure, the IVC-100 had its drawbacks. Because of normal vidicon lag, the camera couldn't be used for fast-moving sporting events. and it could only be panned slowly. But it was ideal for small-budget stations going for color in newscasts and other studio productions: it was just the ticket for low-budget educational broadcasters and certainly well suited for medical, industrial and other CCTV uses. CATV was also high on the list of interested parties, but there was no pressure from the FCC for local program origination at the time.

The IVC-100 was soon followed by the IVC-200—a more expensive ($19,000) version with more bells and whistles, then by the IVC-300, a three-Plumbicon camera priced at $29,000, and the IVC-90 priced at $7,300. It looked as though IVC had the low-cost camera market sewn up for a while, which indeed it did. IVC cameras were also private-labeled and sold by Bell & Howell and by Singer's GPL Division. These two companies also private-labeled IVC's videotape recorder, as did RCA, which still sells the little helical unit. B&H and GPL have both

FIG. 1—SINGLE-TUBE RCA PK-730 determines brightness values of each small area scanned, permitting two carriers to be produced in the decoder. Green is generated electronically.



dropped the IVC line in favor of cheaper Japanese equipment on the market.

While all this was going on, RCA unveiled its coup—the single-vidicon color camera (model PK-730). It was priced (tentatively) at $7,000 or $8,000, but by the time it finally got into production a year later (last November) the price had risen to $9,000 plus, depending on options.

Light entering the RCA camera first goes through the lens and through two striped filters—one of cyan and white stripes and one of yellow and white—before reaching the pickup tube (Fig. 1). The tube target sees the cyan filter as a set of stripes, one half of which (the clear white) transmits all colors and the other half (red stop) transmits cyan. Red information won't pass through the cyan stripe, but will pass the clear stripe, along with all other color information. The same is true of blue light reaching the yellow/white filter. No blue is transmitted by the yellow stripes, but does pass through the white stripes along with all other colors.

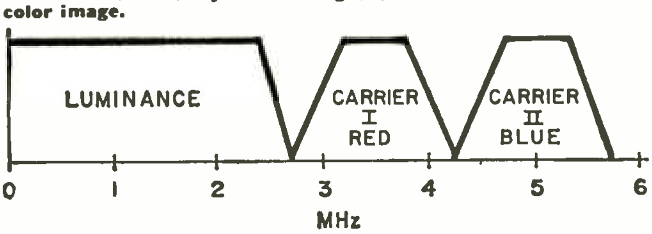
The pickup tube in effect works in reverse; instead of detecting the presence of blue and white information, it detects its absence.

The stripes dissect the image into very small segments, which are encoded in the form of alternating brightness values. A given segment of the target is programed to read red information, another segment blue information. This is fundamentally an area-sharing system since the selected areas of the target must not only produce picture detail, content and brightness value signals, it must also handle color information. The tube is able to distinguish between red and blue since they reach the target at different brightness values. The effective number of stripes for red and blue is different, so that this distinction can readily be made.

The electron beam that scans these stripes generates two carriers which contain the red and blue information (Fig. 2). The luminance occupies the frequency band from 0 to 2.8 MHz, the red signal 2.8 to 4.2 MHz and blue from 4.2 MHz to 5.6 Mhz. The green is derived from the combination luminance (Y) channel by subtracting the red and blue signals.

The camera produces surprisingly good color, although the resolution is limited to 250 lines. This is somewhat better than the 230-line resolution of the average home color receiver, so the two working together in a simple CCTV system can produce excellent results. This resolution is a limiting factor only where broadcast use is involved. The camera simply can't meet broadcast requirements, so it's billed as a unit for CCTV, education, training, military, health sciences and research. It's also dandy for industrial and other quality CCTV work where color is a benefit.

FIG. 2—ELECTRICAL OUTPUT of the RCA one-tube camera. Green is obtained by subtracting red and blue from the full-color image.



STRIPED-FILTER camera from RCA costs about $9,000.

More field-sequential types

First production units of the RCA PK-730 were delivered last fall and full-scale manufacturing is now a reality for the world's only available single-tube color camera. There are other single-tube color cameras—the field-sequential type—mainly made by CBS Laboratories for medical use and by Westinghouse (under CBS license) for the Apollo moon program. The CBS medical version is fairly inexpensive as color cameras go, but backup equipment needed to convert field-sequential to standard NTSC type signals is ponderous and frightfully expensive. The only successful versions of these converters in operation do their work in the Houston Space Flight Center. In the meantime, CBS is working on the electronics for a more reasonably priced converter.

If you want to use the field-sequential single-tube camera in its medical version, you must also buy a monitor similarly equipped with a spinning filter disc. But the monitor screen size is quite small—about 8 inches diagonal—because of the ponderous size of equipment needed to drive the disc in larger-screen versions. One big advantage of the CBS camera—its color rendering at extremely low light levels is quite good.

Other special-purpose and low-cost cameras are on the market. One new unit aimed at the commercial and educational broadcaster is made by Commercial Electronics, Inc., a new California-based company. This camera uses Westinghouse secondary-electron-conduction (SEC) vidicons—the same pickup tube used in the Apollo field-sequential camera. The difference here is that CEI's camera uses three of the SEC's in a rather conventional color-camera setup. Reason for the SEC's: they give the camera extremely high sensitivity and can provide a brilliant full-color picture at normal room lighting (about 10 foot-candles) at a lens opening of *f*8.

To operate at 10 foot-candles, conventional $80,000 TV cameras have to crank the lens wide open, losing depth of field and generating lots of picture noise in the dark areas. The camera is planned for medium- to low-budget operations such as educational and marginal uhf broadcasters who might opt for truly low-cost cameras. This one is tagged at $32,000. Justification for the somewhat higher price than the IVC cameras is the savings in new studio lighting that's not needed. The camera will work beautifully in studios lighted for monochrome; there's no need to add more lights, or more air-conditioning capacity to handle the extra heat, generated by added lights.

Japan: still at three figures

One of two production-model cameras from Japan to use a striped-filter arrangement is the Sony DXC-5000. Priced at about $5,000, this camera isn't simply a rehash of the Nippon Columbia and RCA cameras. Instead it uses other overlapping areas of technology. The striped filter

(*continued on page 62*)

Color-difference amplifiers

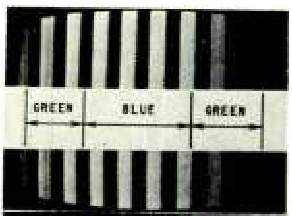
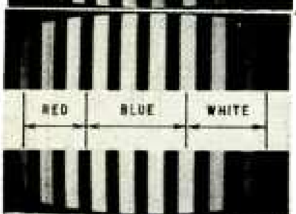
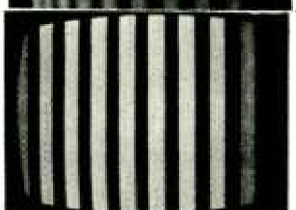
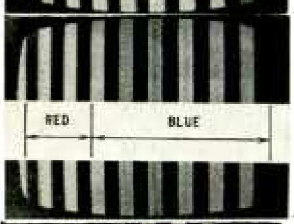
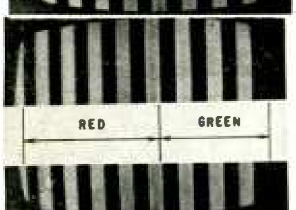
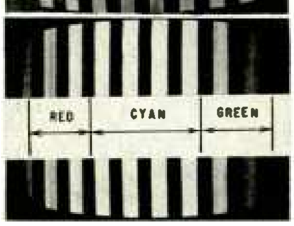
6DM8 or equivalent in tube or hybrid chassis

NEW R-E EXCLUSIVE

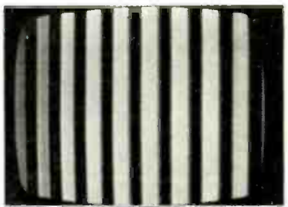
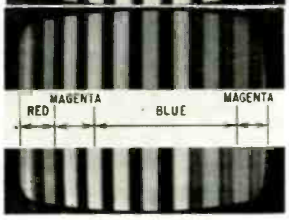
Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES — WHERE TO CHECK FIRST

SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Red missing; green at both sides; blue in middle	plate pin 3	WF5	Any around V1-a
	Colors smeared; green dominates; brightness control not correct	grid pin 8	WF3	L3 R4
	Green missing; no phase change	not much help	WF6	R4
	No color; raster out of focus and shrunk	all plate pins	WF4	R14 V1
	Raster bars all blue	plate pin 3 grid pin 8	WF3 WF6	R2 C4
	Green missing; from right-end bars	plate pin 2	WF6	Any around V1-b
	Blue missing; more than usual red and green	plate pin 1	WF7	Any around V1-c
	Blue very weak; center bars are cyan	plate pin 1 grid pin 9	WF7	C2 R7

*an Easy Read™ feature by FOREST H. BELT & Associates © 1970

SCREEN SYMPTOMS AS GUIDES		WHERE TO CHECK FIRST		
SYMPTOM PIC	**DESCRIPTION**	**VOLTAGE**	**WAVEFORM**	**PART**
	Colors weak and faded, even at high color setting	not much help	not much help	R14 R15
	Blue dominates; green weak or missing. Retrace visible.	grid pin 6 grid pin 8	WF4	R14 blanker connection

NOTES:

Use this guide to help you find which key voltage or waveform to check first.

Study the screen colors, with color-bar generator fed into antenna terminals, the receiver's hue control set at center, and the color control about two-thirds up.

Most helpful clues to the fault are found at key test points indicated in Voltage or Waveform column.

Make the voltage or waveform check indicated for symptoms you see on the screen.

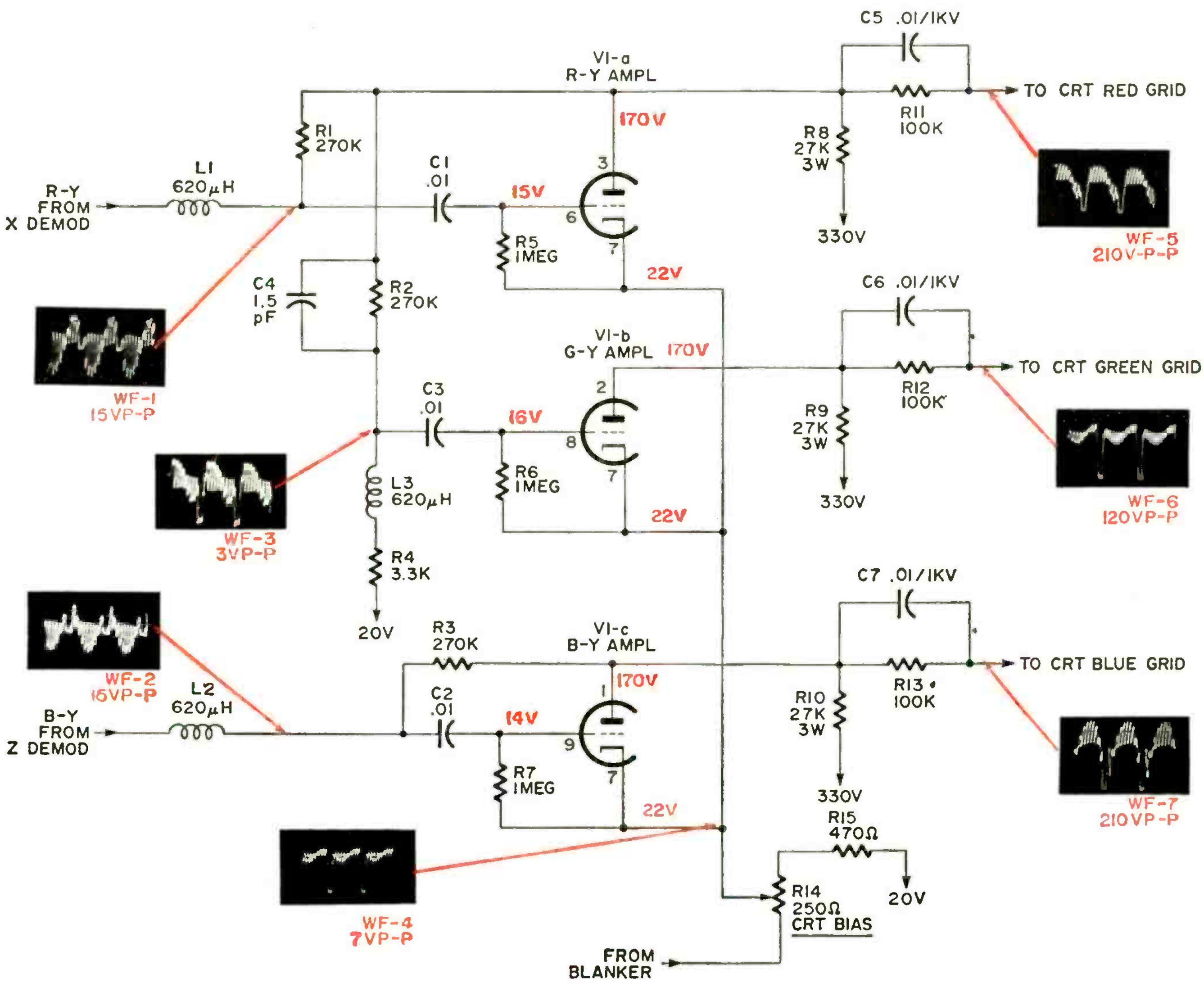
Use Voltage Guide or Waveform Guide to analyze results. For a quick check, test or substitute the parts listed as the most likely cause of the symptoms.

THE STAGES

SOME CHROMA DEMODULATORS HAVE LOW OUTPUT. THE RECOVered color signals need amplification before being applied to the color CRT. In hybrid color TV's, the color-difference amplifiers (as they are called when the Y or brightness component is not part of the demodulated color signal) are almost always tubes rather than transistors.

These color-difference amplifiers are fed from X and Z demodulators (see last month's Kwik-Fix™). An R—Y signal comes from the X demodulator, and a B—Y from the Z

(copy continues on page 38)

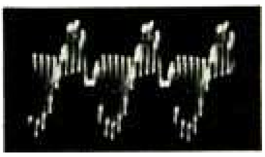


DC VOLTAGES AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
Plate pin 1 Normal 170 V		R10 open	R3 low R7 shorted C2 open L2 open	C2 shorted R7 low		R14 open V1 dead
Plate pin 2 Normal 170 V	R9 open		R4 high R6 low, shorted	R2 low R4 high R14 open at blanker C3 leaky C4 leaky	R4 open L2 open L3 open	R14 open V1 dead
Plate pin 3 Normal 170 V		R1 low	R1 low R5 low, shorted R8 open C1 open, leaky L1 open	R2 low C4 leaky	L2 open	R14 open V1 dead
Grid pin 6 Normal 15 V			R8 open			R5 low, shorted R14 open at blanker C1 open, leaky L1 open
Cathode pin 7 Normal 22 V					L2 open	R14 open
Grid pin 8 Normal 16 V		R4 open L3 open			R2 low R4 high C3 leaky, shorted C4 leaky	R6 low, shorted R14 open at blanker C3 open
Gride pin 9 Normal 14 V			R9 open R10 open		R3 low C3 leaky C3 shorted	R7 low, shorted R14 open at blanker C2 open L2 open

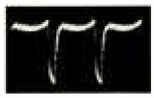
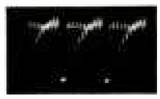
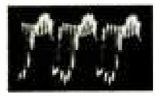
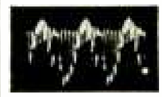
NOTES:
Use this guide to help you pinpoint the faulty part.
All voltages taken with signal from color-bar generator fed into antenna terminals of receiver.
Measure the seven key voltages with a vtvm.
For each, move across to the column that describes the change you find.
Finally, notice which parts are repeated in whatever combination of voltage changes you find.
Test those parts individually for the fault described.
Look for additional clues in the Waveform Guide.

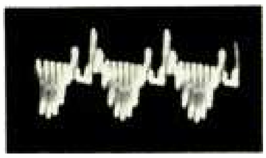
WAVEFORMS AS GUIDES



WF1 Normal 15V p–p

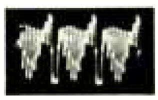
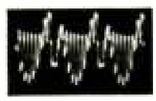
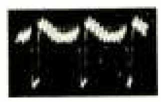
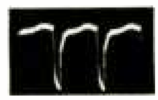
This is the input waveform from the X demodulator. It is red video, but minus the Y portion (R—Y). It is mostly a reference waveform, yet it offers some clues of malfunctions in V1-A. That's because of the small feedback through R1. When phase is right, the third negative bar is longest. Natural blanking is short, and stays near the zero base line.

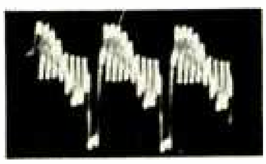
V p-p low	V p-p high	V p-p zero					
	C1 open		 8V p–p L1 open	 7V p–p R1 low	 8V p–p R5 low C1 leaky	 8V p–p R5 shorted	 24V p–p R14 open



WF2 Normal 15V p–p

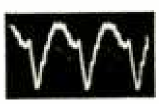
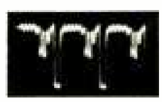
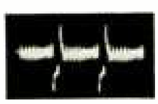
This is the input waveform from the Z demodulator. It is blue video, but minus the Y portion (B—Y). It, too, gives some pretty good clues to malfunctions in the amplifier it feeds, because of the feedback connection through R3. The first two bars go positive. When phase is right, the sixth bar is the longest negative one. Blanking is normally short, staying around the zero base.

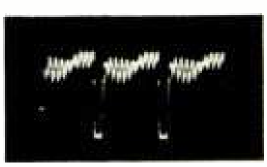
V p-p low	V p-p high	V p-p zero					
	R14 open C2 open		 9V p–p R3 low	 15V p–p R7 low C2 shorted	 10V p–p R7 shorted	 9V p–p L2 open	



WF3 Normal 3V p–p

This is the waveform that is made into green video, also minus the Y portion (G—Y). It comes from the amplified (and inverted) R—Y signal. The amplitude is small because of the tiny value of phase-shifting capacitor C4, which is also the only coupling capacitance. Blanking is tall, having been added in V1-A. The ninth bar should be the longest negative one. Most of the other bars in this waveform are positive, producing no output when they get to the crt grid.

V p-p low	V p-p high	V p-p zero					
	R4 high R6 low R6 shorted C3 leaky C3 shorted		 30V p–p R4 open L3 open	 2V p–p R1 low R8 open	 15V p–p R2 low C4 leaky	 3V p–p R14 open	
			 1.2V p–p R2 open C1 open L1 open	 3V p–p C1 leaky	 1.5V p–p R14 open		



WF4 Normal 7V p–p

This is a combination waveform, taken at cathode pin 7. The blanking pulse dominates it. The cathode is where blanking is fed in. The color-signal portion of the waveform is comparatively small. R—Y seems to dominate that—the third bar is furthest negative. Clues to which tube section is in trouble are found in the polarity and amplitudes of bars in this waveform, if you study them carefully.

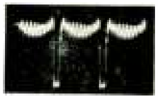
WAVEFORMS AS GUIDES

V p-p low

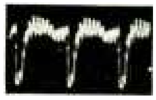
V p-p high

R14 open
R15 open

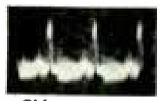
V p-p zero



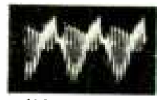
10V p–p
R2 low
R8 open
C1 open
C4 leaky
L1 open



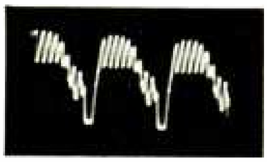
10V p–p
L3 open



2V p–p
R14 open



4V p–p
R14 open



WF5 Normal 210V p–p

Taken at plate pin 3, this is the red output waveform, minus Y of course. Blanking pulses point negative; they cut off the CRT gun during retrace. The third bar is tallest in the positive direction, when phase is right. You can see from the waveform which bars on the screen have some red in them and which have none. The ratio of color-bar signal amplitude to blanking amplitude is important.

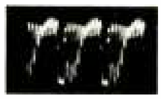
V p–p low

V p–p high

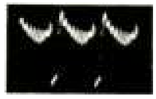
V p–p zero

R14 open
V1 dead

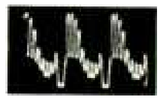
18V p–p
R5 shorted
L1 open



8V p–p
R1 low

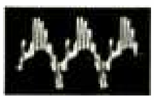


15V p–p
R8 open
C1 open

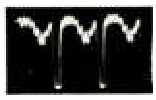


100V p–p
R5 low
C1 leaky

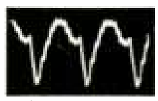
225V p–p
R11 open
R14 open
R15 open



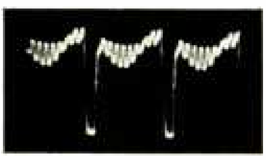
150V p–p
R14 open
at blanker



200V p–p
L2 open



65V p–p
C5 open



WF6 Normal 120V p–p

Taken at plate pin 2, this is the green output waveform, minus Y of course. The ninth bar is furthest positive, when phase is correct. It drives the green gun to highest output in that bar on the CRT screen. Amplitude of the color signal is small, relative to blanking. The green gun of the CRT doesn't need much drive. The green phosphor is the most efficient one, and less of green is needed anyway to make white.

V p-p low

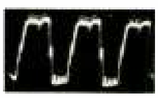
R6 low
R9 open
C3 leaky
C3 shorted

V p-p high

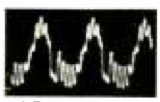
R14 open
R15 open

V p-p zero

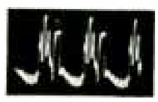
V1 dead



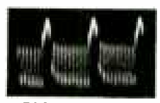
250V p–p
R4 open
L3 open



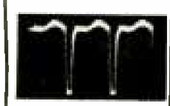
180V p–p
R4 high



90V p–p
R2 low
C4 leaky

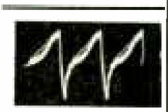


9V p–p
R14 open

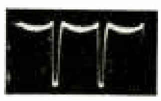


200V p–p
L2 open

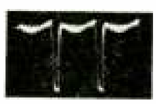
50V p–p
C6 open



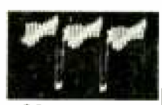
200V p–p
R8 open
C1 open
L1 open



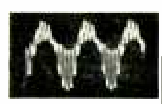
100V p–p
R1 low



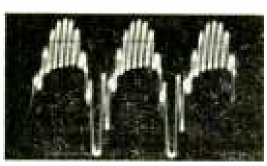
10V p–p
R6 shorted
C3 open



60V p–p
R14 open
at blanker



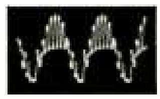
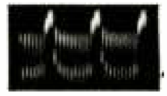
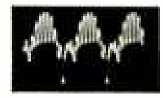
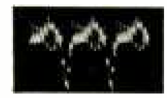
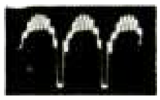
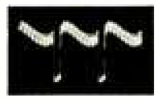
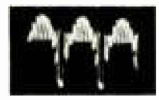
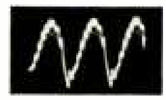
20V p–p
R12 open



WF7 Normal 210V p–p

Taken at plate pin 1, this is the blue output waveform, minus Y. Blanking is negative, as in the other output waveforms. The sixth positive bar is tallest, and drives the blue gun the hardest for that bar on the CRT screen. You can judge the relative amounts of blue in other bars on the screen from how tall the other positive bars are in the waveform.

WAVEFORMS AS GUIDES

V p-p low	V p-p high	V p-p zero					
R3 low		V1 dead	 10V p-p R7 shorted C2 open	 180V p-p R7 low C2 shorted	 5V p-p R14 open	 180V p-p R14 open	 20V p-p L2 open
			 240V p-p R8 open R9 open	 12V p-p R10 open	 18V p-p R13 open	 60V p-p C7 open	

NOTES:
Use this guide and the Voltages Guide to help you pin down fault possibilities.
Waveforms are taken with keyed-rainbow color-bar generator fed into antenna terminals of receiver. Hue control is centered, color control two-thirds up.
With the direct probe of the scope, check the waveforms at the six points shown. Set the scope sweep at H or about 5 kHz, to show three cycles of the waveform.
Note amplitude. If it's missing, low or high, check the parts indicated under those columns.
Note waveshape. Pay special attention to which bars are positive and which negative. Note which is the furthest negative.
If there's a change in waveshape from normal, despite amplitude, check the parts indicated.

demodulator. Those are, respectively, red and blue, both minus the Y signal, which is video or brightness. They are amplified and coupled to the red and blue CRT grids. (Video is fed from other stages to the CRT cathodes).

That leaves green unaccounted for. The G—Y signal is developed from a phase-shifted version of the R—Y, mixed against the R—Y/B—Y by a common cathode inside the tube.

Output levels of the color-difference amplifiers aren't all the same. Green is least, because the CRT's green phosphor doesn't need as much excitation as do the red and blue. Some chassis have drive controls between the color-difference amplifiers and the CRT grids. They let a technician adjust best gray-scale tracking at high brightness levels.

The R—Y signal comes through L1 from the X demodulator. It is applied by C1 to the grid of V1-a. Resistor R5 is the input load.

The B—Y signal comes through L2 from the Z demodulator. Capacitor C2 applies it to the grid of V1-c. Resistor R7 is the input load for that tube section.

After amplification in V1-a, some of the R—Y signal is fed through a phase-shift network to V1-b. The phase shifting is done by C4–L3. Resistor R2 is not meant to be part of the phase network; it's an impedance-balancing resistor, to match feedback resistors R1 and R3. However, it does have some effect on phase.

This phase-shifted R—Y sample is fed by C3 to the grid of V1-b. The cathode in V1-b is the same cathode as in V1-a and V1-c (they're only drawn separate on the schematic). A direct mixture of the R—Y and B—Y signals is thus applied to V1-b by the common-cathode arrangement. They beat against the phase-shifted grid signal and produce a G—Y or green color-difference signal that is amplified by V1-b.

Capacitors C5, C6 and C7 couple the red, green and blue color-difference signals to the red, green and blue grids of the color CRT. However, resistors R11, R12 and R13 maintain dc continuity to the CRT grids from the plates of the tube sections. The values of these resistors and capacitors were chosen carefully, because they exert an equalizer influence on the output signals.

A blanking signal is fed to the common cathode through R 14. Amplitude of the blanking pulses depends only slightly on the setting of R14.

The supply connections for plate voltages are simple in these stages. Resistors R8, R9 and R10 are wirewound 3-watt resistors. They bring dc from the 330-volt line to the plates.

There is a dc connection from the plates of V1-a and V1-c back to the demodulators, through R1 and R3. But they have little effect on the dc operation of the color-difference amplifiers. Likewise, the connection to the 20-volt line is just a handy ground return for phase-shift network C4–L3 and load resistor R4.

The grids are returned to cathode through three 1-meg-ohm resistors: R5, R6 and R7. Grid bias is largely contact bias.

The cathode, common to all three tube sections, isn't returned to ground directly. It connects to the slider of R14. One end of that potiometer goes to the 20-volt line. The other goes directly (or through a decoupling choke) to a blanker transistor stage. Either end of R14 is thus a form of ground return.

All three plates are dc-connected to the CRT grids. The voltage on them therefore partially determines the operating point of the CRT guns. So, potentiometer R14 can, by setting average operation of the three tubes, control CRT bias to a limited degree. The dc voltage at cathode pin 7 comes mainly from the blanker transistor stage (not shown).

SIGNAL AND CONTROL EFFECTS

Changes in the level of station signal have very little effect on these amplifiers. There are slight variances in dc voltages when chroma levels change.

Varying the color control (back in the chroma section of the receiver) does alter the level of color signal in the waveforms. It doesn't affect the overall amplitude of waveforms that have the blanking pulse. That's because blanking has more peak-to-peak amplitude than the color-difference signals.

The hue or tint control can change the relative phase in color-signal waveforms. Phase is shown by which bars are positive-going and which negative, and which bar in a group is tallest.

Dc operation of the stages is changed by adjusting the CRT BIAS control (R14) in the cathode circuit. It also slightly changes the overall amplitude of the blanking pulse in waveforms that include blanking. For troubleshooting, it's best to have the CRT BIAS at midrange.

QUICK TROUBLESHOOTING

Be sure color control is turned about two-thirds up, and hue is set at midrange. Always use a keyed-rainbow generator and scope. Dc measurements are helpful in some cases, but the best clues are in the waveforms.

In studying the waveforms, watch for several things: (1) Note the relative amplitude of color signal vs blanking pulse. (2) Note overall amplitude. (3) Note the shape of the color-signal portion of the waveform; it's very important. () Note the shape of the blanking pulse, whether it's the natural blanking that comes with the signal from the demodulators or the added tall pulse you see in the cathode and output waveforms.

Keep in mind that the input of the G—Y amplifier (WF3) comes from V1-a. That's why troubles you think should affect only red may also affect green. You track the trouble back to its actual source with your scope. **R-E**

44 MOS IC's make a wristwatch digital clock

A REVOLUTION IN TIMEKEEPING HAS OCCURRED IN THE past few years. We've seen the appearance of the electric watch; then the electronic watch and digital clocks—and now a digital wristwatch.

The newest timepiece is the Hamilton Pulsar, a solid-state, time-indicating wrist computer. It's an all-electronic timepiece that has no moving parts. Instead it is made up of three major electronic sections:

1. A rechargeable 3-cell 4.5-volt battery.
2. A high-frequency quartz crystal.
3. A computer module with microminiature logic and display circuits.

The high-energy main battery, which takes up 80% of the total volume of the case, excites a quartz crystal, which oscillates at 32,768 Hz. This battery also maintains the charge in a similar, but much smaller, sustaining battery that continuously drives the logic circuitry. The main battery measures a mere 1.035 x 1.4 x 0.196 inches.

The computer's integrated circuits, hybrid-circuit logic substrates, display substrates and all wiring are ultrasonically bonded and mounted on separate gold-plated shim plates of 0.015-inch thick beryllium copper. The shim plates with their circuitry are screwed together, back-to-back, and form a fixed-program computer about a tenth of an inch thick. The assembly is potted in epoxy for physical protection and cannot be jarred out of order.

The logic circuitry consists of seven individual hybrid circuits that contain 44 complementary-symmetry metal-oxide semiconductor (MOS) integrated circuits. They are equivalent to 3,474 npn and pnp transistors.

The oscillator and countdown circuit generates the primary frequency and divides it down by a factor of two. The 14-stage divider provides five different frequencies for various functions, which are fed to other circuits.

The operational control circuit times the length of display of the hours and minutes digits, which is set at 1¼ seconds, on command, when the push button on the face of the timepiece is depressed. The same logic circuit supplies a signal that causes the seconds display to light following the minutes display if the pushbutton is held down. A third function of this circuit is to control the setting of the minutes display. Setting the minutes, in turn, generates a signal to reset the seconds to zero, thus stopping the display circuits until the timepiece is restarted. This does not interrupt the accurate timekeeping capability of the logic circuits, since the oscillator keeps running.

Another logic substrate, the seconds counter circuit, counts the seconds and allows for zeroing the seconds display. It also generates the signal that makes the minutes display change from 59 to 00 at the proper times.

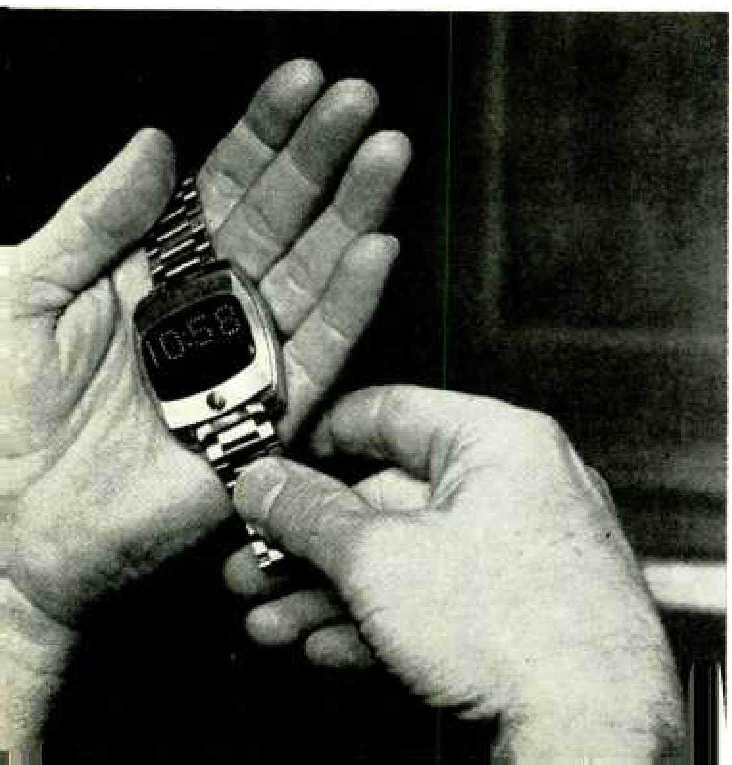
The minutes counter counts the minutes and generates a signal that causes the hours display to change from 12 to 1 in a 12-numeral sequence.

The hours circuit counts the hours from 1 to 12.

An automatic light-level control supplies signals to three light sensors that are mounted on the display assembly. These sensors measure ambient light levels. As ambient light gets brighter, the sensors lengthen the duty cycle of the light emitting diodes (LED's) that form the numerals, thus giving the effect of increased brightness to make the numbers easier to read in daylight.

The last of the logic circuits is the power switching circuit. It supplies power to six display decoders. These units, one for each digit, are fed the BCD (binary coded decimal) information from the counter circuits and convert these pulses into numbers.

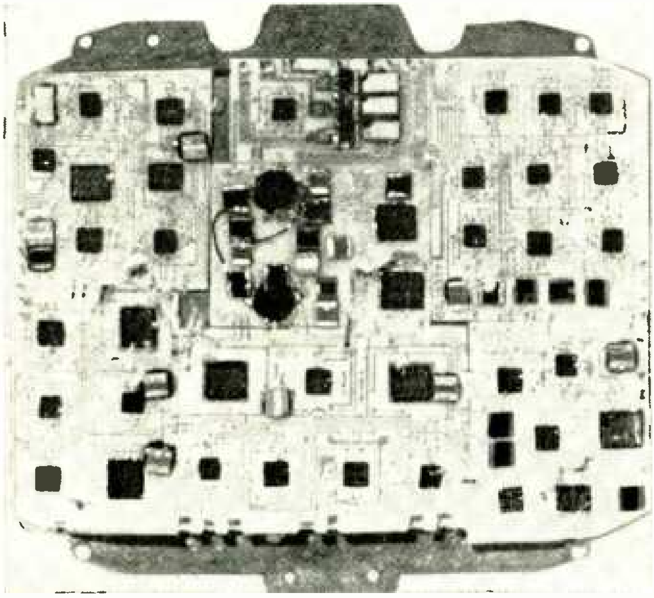
The LBD's, measuring 0.021-inch square, are arranged in 27-dot matrices, one for each numeral. One of these matrices, however—the tens digit of the hours display—needs only seven diodes to form the numeral 1.

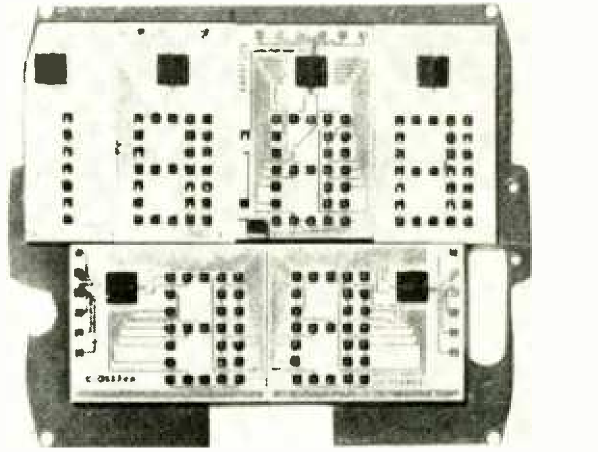


electronic timepiece on your wrist

by LARRY STECKLER

MANAGING EDITOR





SEVEN INDIVIDUAL HYBRID CIRCUITS on alumina-oxide substrates (left) make up the logic circuitry inside the Pulsar watch. THE READOUT SUBSTRATES (above) are on a separate module and consist of arrays of gallium-arsenide light-emitting diodes. Also located on this substrate is an automatic light-level circuit that varies the brightness of the readouts according to ambient light conditions.

This timepiece has extremely high accuracy, since its basic operating frequency is four times greater than that used in electromechanical quartz-crystal watches. This makes it possible to keep time deviation to less than 3 seconds per month. In addition, since there is no mechanical gear train, the electronic timepiece is not affected by its physical position. This does have a great effect on the accuracy of standard electronic watches.

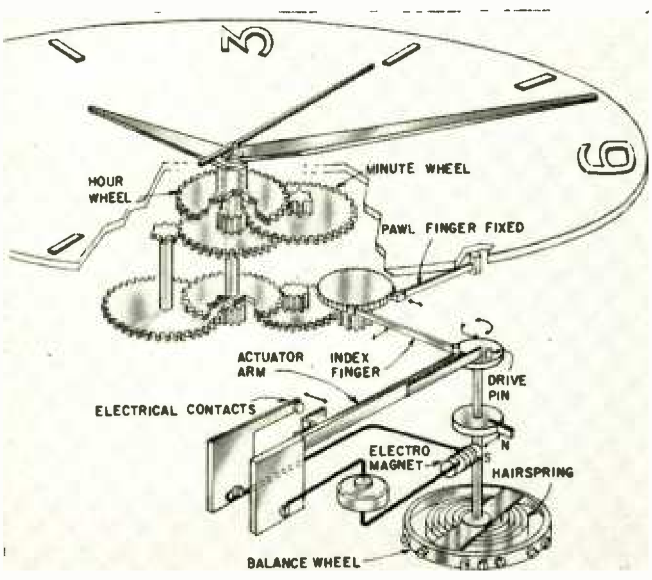
The three-cell rechargeable battery was specially designed and built for this application. Under normal use it will power the Pulsar timepiece for up to six months. The timepiece comes with a spare battery and recharger. The spent battery is removed by unscrewing the back of the case and the fully charged spare is inserted. No accuracy is lost when batteries are changed. There is a second battery permanently located inside the electronic module that will provide power while the main battery is replaced.

One of the most important features of Pulsar is that since it has no moving parts, nothing can fail because of friction or wear. As a further assurance of durability, all components, including wires, are potted. Since there is no conventional stem for winding or setting, the stem-sealing problem is totally eliminated, making it relatively easy to waterproof the timepiece.

Should it be necessary to reset the time, all the owner need do is depress one of two marked recesses on the rear of the case. One recess rapidly advances the hours without disturbing either the minutes or seconds. The other recess automatically sets the seconds reading

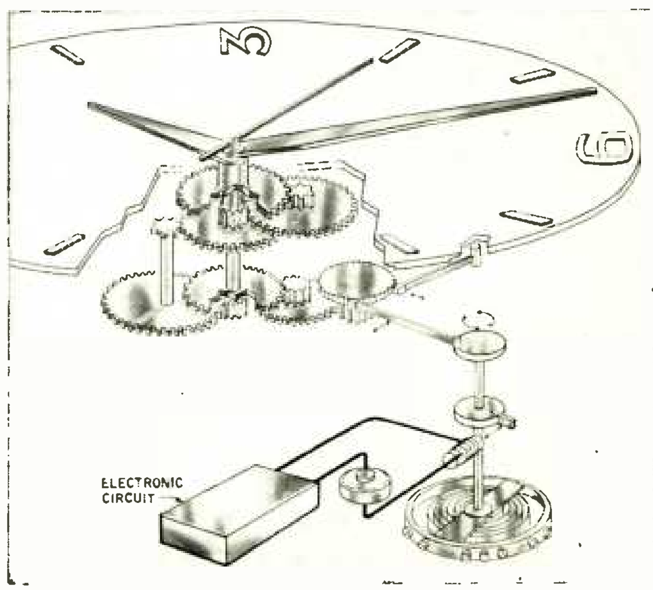
BASIC ELECTRIC WATCH

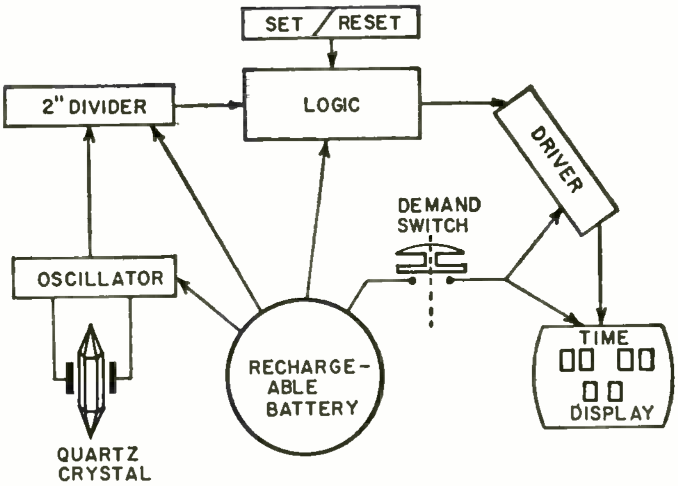
Power is provided by a miniature battery and is transmitted to the balance wheel by electromagnetic impulses initiated by make-and-break contacts, operated by the balance wheel. Accuracy is controlled by the oscillating rate of the balance wheel. Watch hands are turned by a gear train which is driven by the oscillation of the balance wheel. The watch will run for the life of the battery.

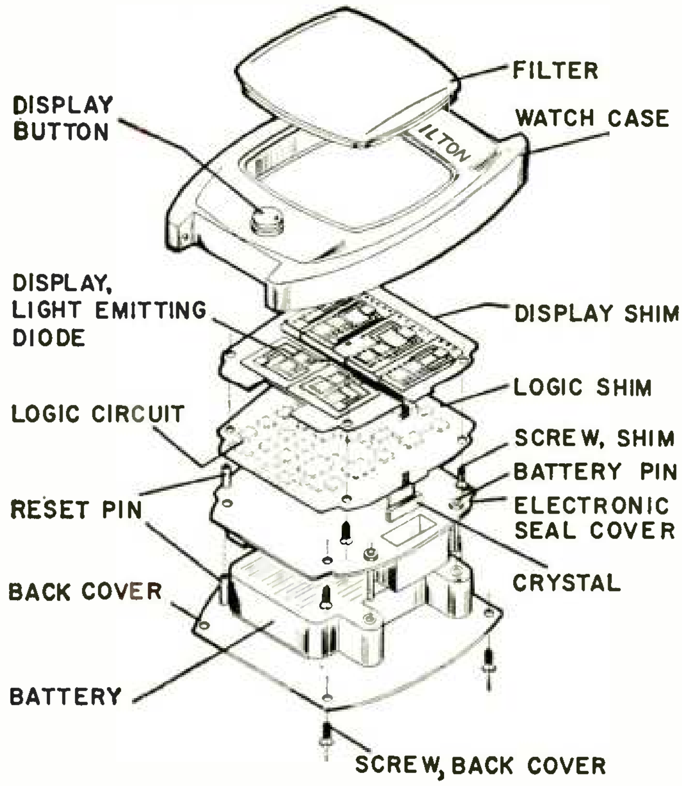


BASIC TRANSISTOR WATCH

Power is provided by a miniature battery and is transmitted to the balance wheel by electromagnetic impulses regulated by a transistor circuit. Accuracy is regulated by the oscillating rate of the balance wheel. Watch hands are turned by a gear train driven by oscillation of the balance wheel. This differs from the basic electric in that a transistor replaces the mechanical contacts.







BLOCK DIAGRAM OF WATCH CIRCUITRY (above) gives a basic picture of how the Pulsar works. The quartz-crystal oscillator delivers a high-frequency signal to the divider. This signal is then processed by the logic circuits, fed through the driver and when the demand switch is depressed, activates the readout. EXPLODED VIEW OF THE WATCH (right) shows how it is put together. Note that the battery takes up the largest amount of the total size of the unit. Then there is a seal over the battery, the two IC shims and the case. The total package is about the same size as a modern man's wristwatch. Hamilton reports that a ladies version is not yet available. The smaller size of a ladies watch presents, what are at this time, impossible problems.

at zero while advancing the minutes.

For those readers interested in a brief history of telling time, the first recorded instance of time-telling by measured flow occurred in China over 4,000 years ago. The Emperor, Hwangti, invented a water clock consisting of a pierced brass bowl floating in a basin of water. Hours were calculated by the amount of time it took the bowl to submerge.

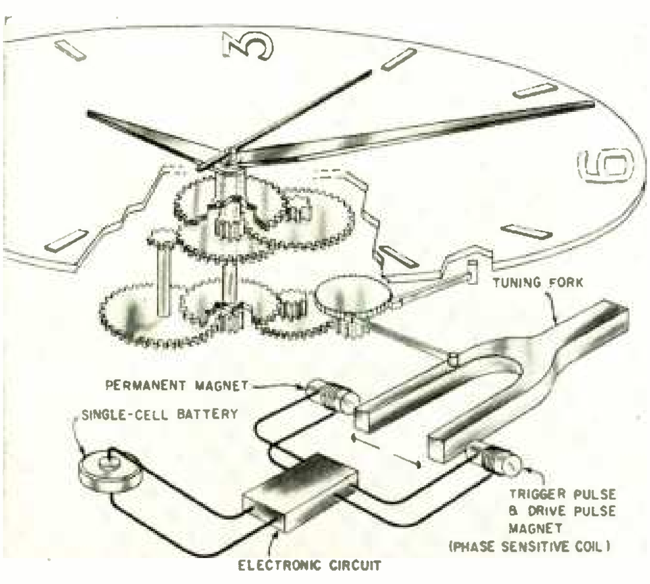
Later, the Greeks developed and refined the Clepsydra (water clock). In other parts of the world, forerunners of the hourglass were being devised.

During the Crusades, mechanical time contrivances, operated by weights were brought to Europe from the East. In 1480, Peter Henlein, a Nuremberg locksmith built a portable, mechanical spring-driven timepiece. It had a single hand to tell the hours. The first wristwatch appeared in 1571. In 1670 a minute hand was added and in 1685, the balance wheel, a must in an accurate watch.

By contrast today we have the Pulsar. **R-E**

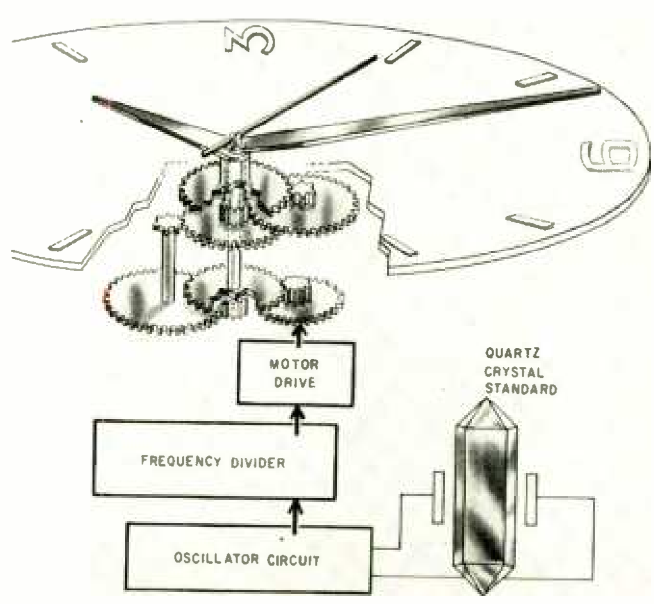
BULOVA ACCUTRON SYSTEM

Power is provided by a miniature mercury battery and is transmitted to the tuning fork by electromagnetic impulses, initiated by a sensing coil and controlled by an electronic circuit. Accuracy is inherent in the natural vibrating frequency of the tuning fork. The watch hands are turned by a gear train driven by the tuning fork vibrations. The watch will run for the life of the battery.



QUARTZ CRYSTAL WATCH

Power is provided by a miniature battery. An electronic quartz-crystal oscillator delivers high-frequency electronic impulses to a frequency divider. Its output drives a motor that drives the watch hands. Accuracy is dependent upon the crystal oscillator's frequency, which is controlled by the inherent frequency of the quartz crystal. The watch will run for the life of the battery.



"CIE training helped pay for my new house," says Eugene Frost of Columbus, Ohio

Gene Frost was "stuck" in low-pay TV repair work. Then two co-workers suggested he take a CIE home study course in electronics. Today he's living in a new house, owns two cars and a color TV set, and holds an important technical job at North American Aviation. If you'd like to get ahead the way he did, read his inspiring story here.

If you like electronics—and are trapped in a dull, low-paying job—the story of Eugene Frost's success can open your eyes to a good way to get ahead.

Back in 1957, Gene Frost was stalled in a low-pay TV repair job. Before that, he'd driven a cab, repaired washers, rebuilt electric motors, and been a furnace salesman. He'd turned to TV service work in hopes of a better future—but soon found he was stymied there too.

"I'd had lots of TV training," Frost recalls today, "including numerous factory schools and a semester of advanced TV at a college in Dayton. But even so, I was stuck at $1.50 an hour."

Gene Frost's wife recalls those days all too well. "We were living in a rented double," she says, "at $25 a month. And there were no modern conveniences."

"We were driving a six-year-old car," adds Mr. Frost, "but we had no choice. No matter what I did, there seemed to be no way to get ahead."

Learns of CIE

Then one day at the shop, Frost got to talking with two fellow workers who were taking CIE courses... preparing for better jobs by studying electronics at home in their spare time. "They were so well satisfied," Mr. Frost relates, "that I decided to try the course myself."

He was not disappointed. "The lessons," he declares, "were wonderful—well presented and easy to understand. And I liked the relationship with my instructor. He made notes on the work I sent in, giving me a clear explanation of the areas where I had problems. It was even better than taking a course in person because I had plenty of time to read over his comments."

Studies at Night

"While taking the course from CIE," Mr. Frost continues, "I kept right on with my regular job and studied at night. After graduating, I went on with my TV repair work while looking for an opening where I could put my new training to use."

His opportunity wasn't long in coming. With his CIE training, he qualified for his 2nd Class FCC License, and soon afterward passed the entrance examination at North American Aviation. "You can imagine how I felt," says Mr. Frost. "My new job paid $228 a month more!"

Currently, Mr. Frost reports, he's an inspector of major electronic systems, checking the work of as many as 18 men. "I don't lift anything heavier than a pencil," he says. "It's pleasant work and work that I feel is important."

Changes Standard of Living

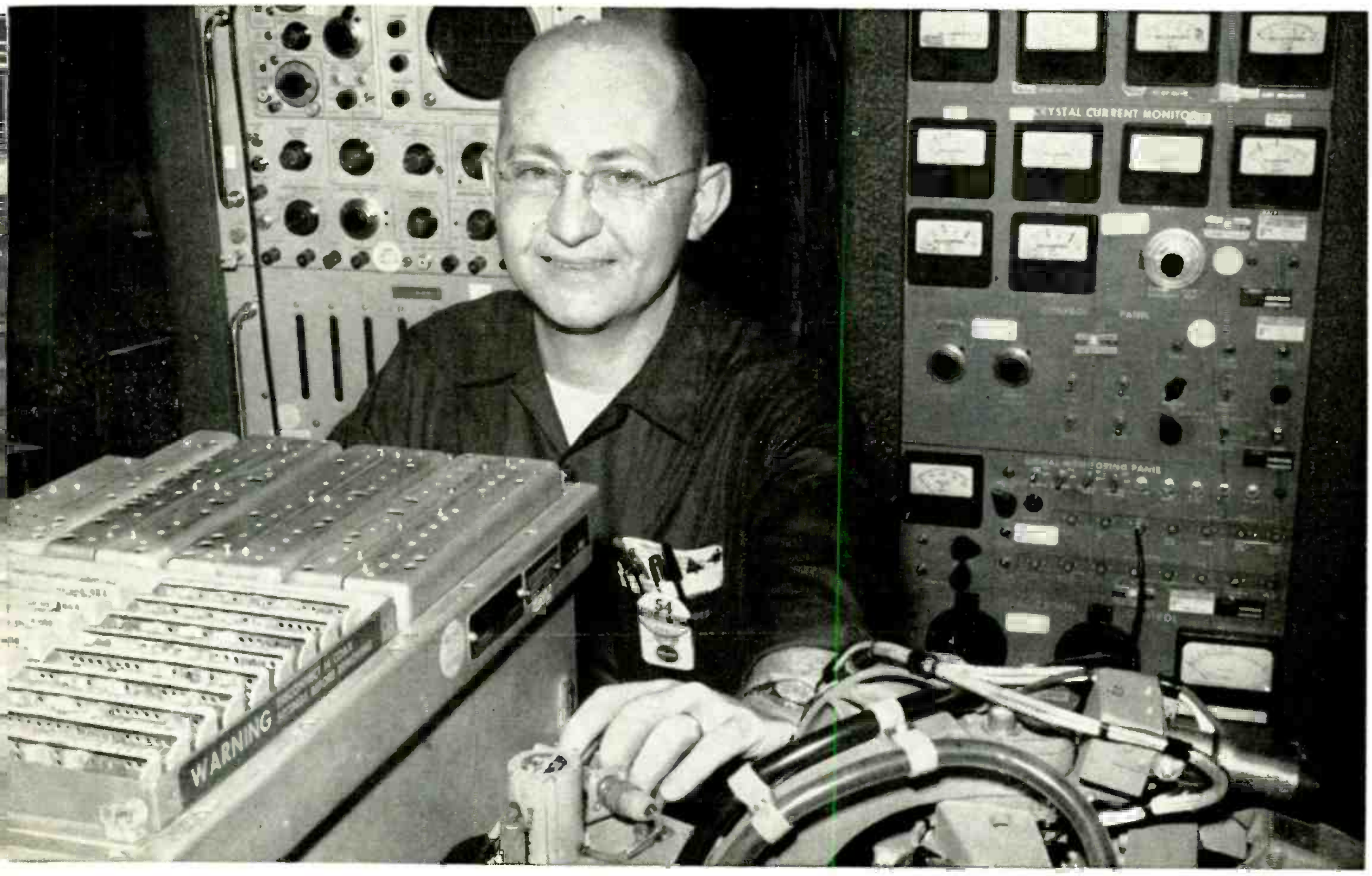
Gene Frost's wife shares his enthusiasm. "CIE training has changed our standard of living completely," she says.

"Our new house is just one example," chimes in Mr. Frost. "We also have a color TV and two good cars instead of one old one. Now we can get out and enjoy life. Last summer we took a 5,000 mile trip through the West in our new air-conditioned Pontiac."

"No doubt about it," Gene Frost concludes. "My CIE electronics course has really paid off. Every minute and every dollar I spent on it was worth it."

Why Training is Important

Gene Frost has discovered what many others never learn until it is too late: that to get ahead in electronics today, you need to know more than soldering connections, testing circuits, and



replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

How can you get the training you need to cash in on this booming demand? Gene Frost found the answer in CIE. And so can you.

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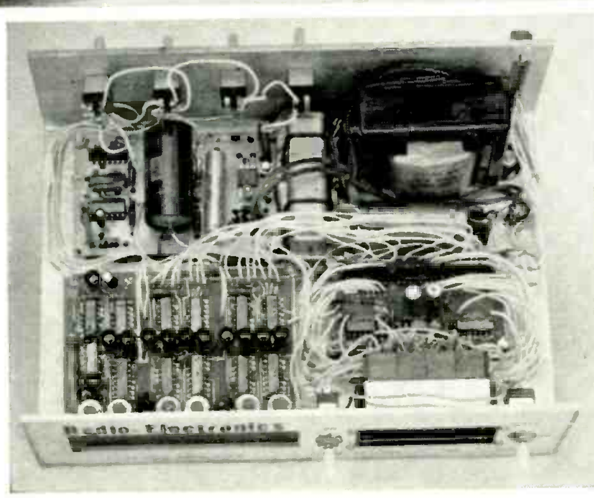


BUILD Multipurpose IC Digital Clock

by LEO WALKER

Build the version that fits your needs and budget.

12- or 24-hour readout with alarm and 10-minute timer.

Economy clock costs under $100

SIMPLICITY AND LOW-COST IC'S MAKE THE cost of constructing a purely all electronic clock quite attractive. The clocks described here have been designed with flexibility in mind, so the reader can select features and price.

Electronic clocks are quiet and can be repaired relatively easily. The clocks described in this article use basically the same scheme in the seconds and minutes sections (see Fig. 1). BCD (binary coded decimal) readout is also available.

Twelve- and 24-hour clocks differ in the setting of the time after the first 12 hours. The decoding for a 12-hour clock requires a few more components since a "one" must be generated so that the clock reads 1:00:00 a.m. or p.m. (See Figs. 2 and 3). The 24-hour unit resets to zero on the next clock pulse after 23:59:59 while the 12-hour version resets to 1:00:00 on the next clock pulse after 12:59:59.

The clock-pulse generator (See Fig. 4) divides the line frequency by 60 or 50 so that the clock will work on 50 or 60 Hz power lines. Five optional features are also provided:

1. Alarm circuit (Fig. 5)
2. Start and stop (Fig. 4)
3. BCD outputs for driving recorders or timed control circuits (Fig. 2)
4. Stopwatch (Fig. 4)
5. Ten minute tone for amateur use (Fig. 7)

The alarm circuit functions as in a regular clock; four switches are used to program the alarm. It can be set to the minute.

The clock can be zeroed and used as an elasped-time meter. The true BCD outputs are available for driving recorders or printers, or as a master clock to control a series of readouts at other locations.

SOME USES FOR A 24-HOUR CLOCK

24 hour clocks with BCD outputs are useful for a number of jobs which in the past have been done by motor driven cams and the like. Some of these uses require additional logic. However, the BCD output provides the Information to control the function shown in the list below.

1. Used to turn lights on and off at periodic intervals such as:
   a. When you are away on vacation to make the prowlers think you are home
   b. To control a Christmas Tree lamp display
2. Water the lawn
3. Open doors and windows for pets or call them
4. Drive electronic calanders
5. Cuckoo clock driver
6. Automatic burglar alarm starter
7. Crank up the car in cold weather
8. Feeding periods
9. Sun lamp timer
10. Sick room medicine caller
11. Control remote readouts

A digital clock can be used to control a lot of the routine functions at home. In fact, it's quite possible that an electronically controlled job manager could help a lot in some households.

The clock can be used as a stopwatch with a maximum time of 12 or 24 minutes. The 60 Hz is applied to the seconds input so that readings to 1/60 of a second are available.

Operation & double boards

These clocks use Motorola MC780P decade counters, MC9760P decoder drivers, and the Burroughs B5750 readout tubes.

The 24-hour reset operates when the MC724 decoder circuit sees the number "24," pins 8 and 5 go high causing the trigger circuit, a μL914, to reset the hours section to zero.

The 12-hour reset is a little more sophisticated. When the decoder sees the number "13," a one-shot multivibrator causes the hours section to reset to zero. When the hours return to zero, a second one-shot sets "1" in the hours section. The clock now reads 1:00:00.

Even though a full readout is shown the cost can be reduced by not reading out the seconds. The approximate cost of this version is $95 to $100, depending on what you have in the junk box.

Double-sided boards are used in this clock to reduce the number of jumpers required to a minimum. If you plan to make your own boards, I suggest that you make a sample run first. The trick is to make a sandwich out of the two negatives.

The top and bottom negatives have to register (that is, holes on the top piece must match those on the bottom). The two pieces are then attached to the support piece. The material is held in place by a piece of tape. The board is exposed on both sides and then developed as usual.

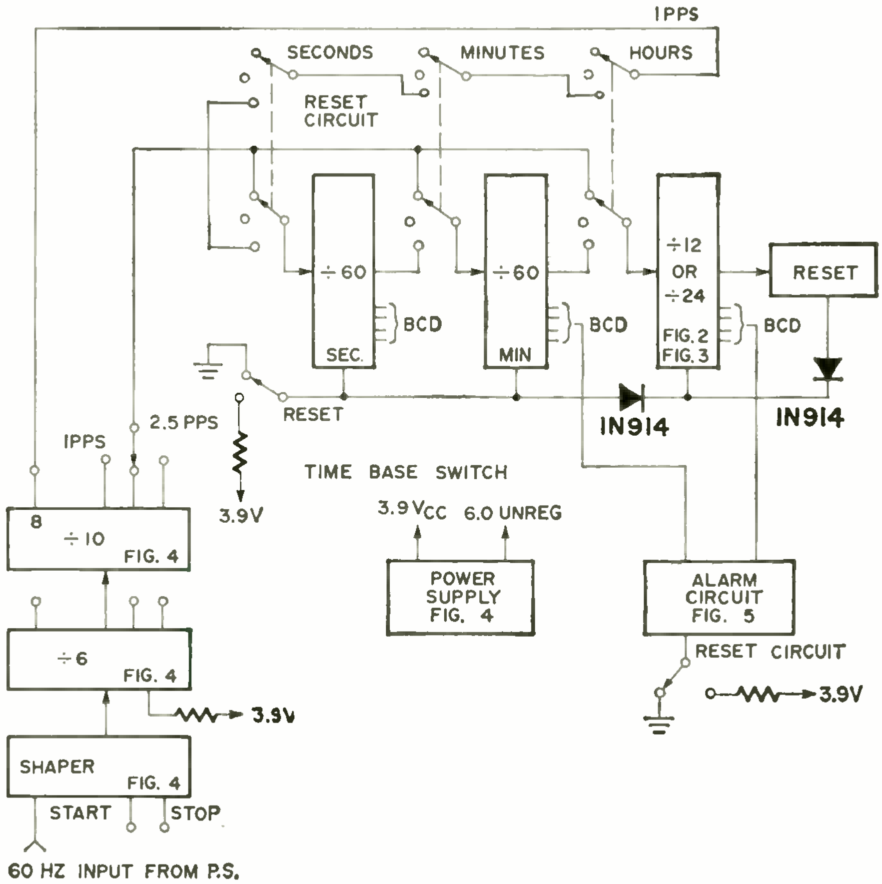
Registration is most important so check your sandwich closely while making the jig. Check the IC pads to make sure that they register.

A few practice runs should be made before the final board is made. Double-sided boards are tricky, but with some practice a first class job is possible.

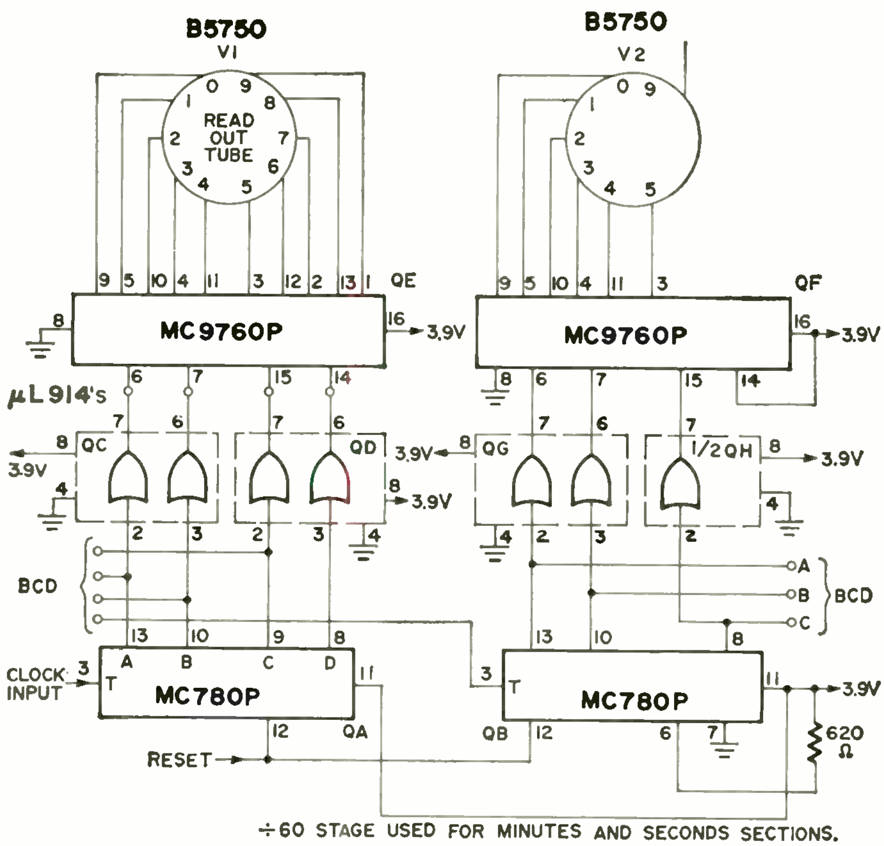
There are a few precautions for those unfamiliar with the double-sided boards used in this unit. Double check the board for shorts that may have gotten through inspection. Use a sharp razor-blade knife to clean the board between the circuits. Use a scriber on the area between the lines. Some of the leads to the packages must be soldered on the top and bottom. Only those leads which are "active" should be soldered. A small sharp-tipped, 25-watt (1/8-inch or smaller tip) iron and low-melting-point solder, preferably the smaller wire-size type, should be used. If boards are pretinned they solder easily. Mount the μL914's (do not cut the leads) first, MC780P's and other IC's next and finally the Nixie tubes. Leave about ½ inch between the board and the tube base.

Circuit description

Fig. 1-a shows the block diagram and Fig. 1-b wiring diagram of the divide-by-sixty stage used in the seconds



(a)



(b)

FIG. 1-a—DIVIDE-BY-60 STAGE is shown in the block diagram. b—This is a detailed wiring diagram of the divide-by-60 stage.

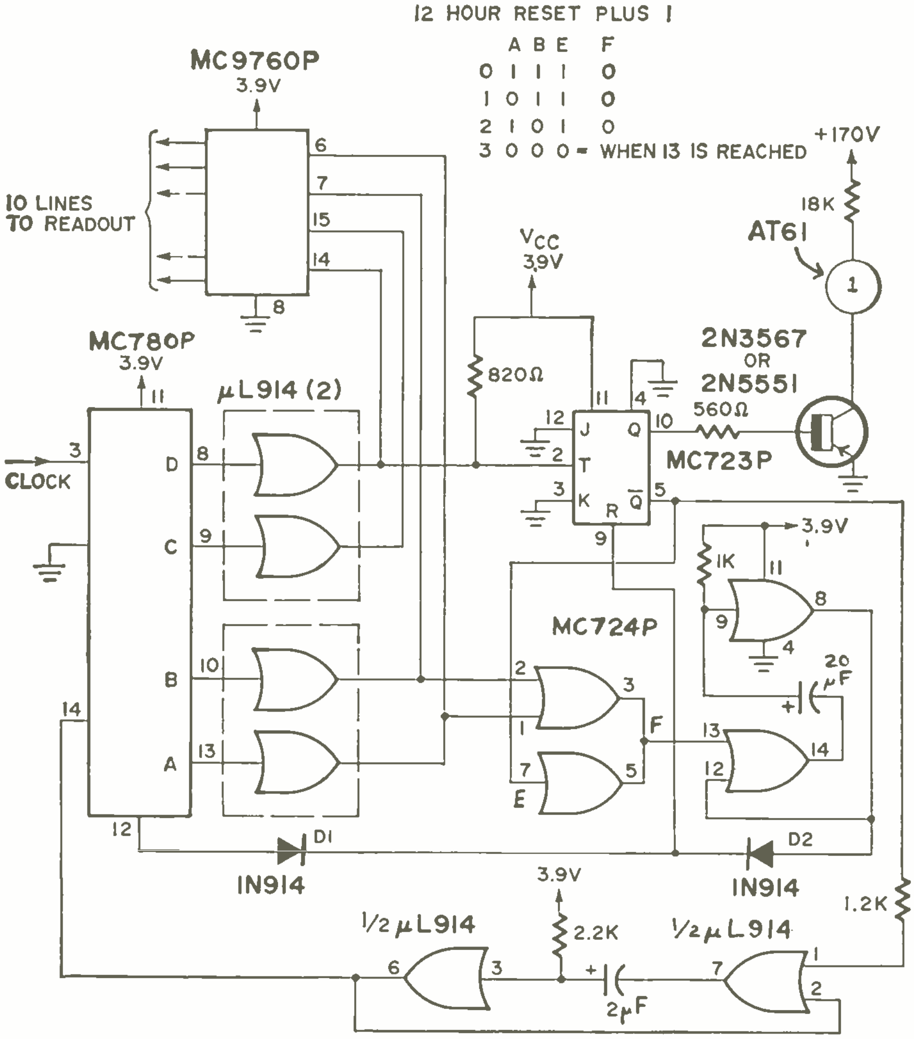
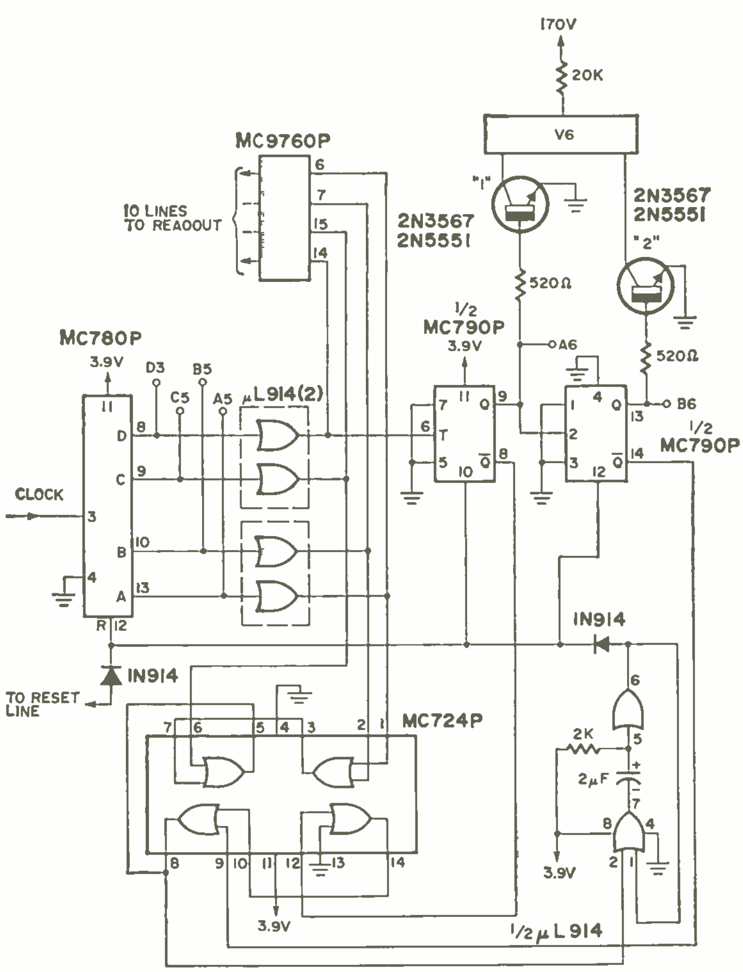


FIG. 2—DIVIDE-BY-12 STAGE (above) sets clock to "1" when count of "13" is reached.
FIG. 3—24-HOUR OUTPUT SECTION resets "24" to "00" so quickly it isn't seen.



and minutes portion of the clock.

Counter QA is a divide-by-ten stage and its output is connected to a divide-by-six stage, QB. The MC780P will function as divide-by-six stage when set "C" lead (pin 6) is tied to V_{cc} (+3.9V) through a 620-ohm resistor. The two units will count for 0 to 59 and the reset. QE and QF are MC9760P decoder drivers and drive readout tubes V1 and V2.

Fig. 2 shows the ÷12 stage. A ÷10 stage (MC780P) drives a MC723P flip-flop. At the end of a 9 count, pin 10 of the ff goes high and turns on the digit "1." The ÷10 resets to zero (10:00:00). When the count of 13 is reached, point "F" goes high, driving the reset one-shot, which causes the hours ÷10 and ff to set zero. When pin 5 of the ff goes high due to the reset action, the second one-shot multivibrator fires and drives the "set 1" input of the ÷10. The clock now reads 1:00:00.

The time-constant of the second one-shot is approximately twice as long as the reset one shot. This assures that reset zero and set 1 functions occur in order. Diodes D1 and D2 direct the reset pulses when the clock is being used as a time-interval meter or stopwatch.

The 24-hour output section is shown in Fig. 3. Two flip-flops are used to indicate "1" and "2" (Example 10:00:00 and 20:00:00). When the MC780 ÷10 stage reads "4" and the "2" flip-flop is on, pin 8 and 5 of the decoder go high, driving the one shot circuit which causes the hours section to reset to zero. (The action is so fast that 24:00:00 is not seen). The two 1N914 diodes direct the reset pulse when the clock is being used as a stopwatch or interval timer.

The power supply and clock pulse generator are shown in Fig. 4. One-half of a MC724 is used as a shaper. Its output is controlled by the remaining half of the package which is wired as a reset flip-flop. This ff is used for the stopwatch function. This ff and the set switch at 60 pps, makes the clock a time interval meter or stopwatch, capable of measuring time intervals to 1/10 of a second. Two MC780P's function as a ÷60 stage: various outputs from 60 pps to 1 pps are available for driving the clock. Two remote connections are provided for controlling the clock as a stopwatch. The power supply is adjusted for 3.9 volts by varying R5 a small amount.

The alarm circuit is shown in Fig. 5. Three MC770P decade decoders drive a detector circuit made up of two MC724P packages. The input to the alarm circuit are the BCD outputs from the minutes and hour section of the clock.

The four switches select the time that the alarm is to be energized. When the correct count is reached all inputs from the switches are high. The QD 14 and QF 8 pins drive the reset flip-flop pin 8 to ground allowing pulses from the tone generator to drive the output transistor and speaker. The time-constants of the tone generator have been selected to give a ragged tone to help dig you out of the deep slumber! A manual reset is available, to turn the alarm off.

If the 24-hour version of this clock is used, the alarm will trigger every 24 hours so there is no need to turn the alarm power switch off if you get up at the same time or need a timed output. A test lead is available to check all the circuitry after the selector switch.

The digital clocks shown here have many possibilities. A complete clock with alarm circuit or a basic clock for around the house viewing or as a programmer. Only a few of the uses are shown. As the price of the IC's used in this clock drop (further we hope), this project should appeal to those of you who would rather wait. The MC780P is currently priced at $3.40 and the MC9760 decoder at $5.55. The B5750 is $6.50 in small quantities.

The remainder of this article, consisting of descriptions of some of the add-on circuits and parts-placement drawings will appear next month in RADIO-ELECTRONICS. More circuitry appears on the next two pages.

PARTS LIST
12- and 24-Hour Digital Clocks

	24 Hour	No. Seconds	12 Hour	No. Seconds
B5750	6	4	5	3
MC9760P	5	3	5	3
MC780P	5	5	5	5
ML914	11	7	11	7
MC790P	1		None	
MC723P	None		1	
MC724P	1		1	
20 μF	None		2	
2 μF	1		1	
IN914	2		2	
2N5551	2		1	
Colons (Neons)	4	4	4	2
Digit "1"	None		1	
620-2	4		3	
2000 ohms	1		1	
1000 ohms	None		1	
Circuit board	1		1	

Power Supply and Clock Pulse Generator

MC780	2
MC724	1
Power transformer	1
2N5296	1
2N5183	2
Diodes	5
Zener	1
Switches	1
Circuit board	1
500 μF/25 Vdc	1
20 μF/250 Vdc	1
100 μF	1
.01	1
2 μF	1
100K/2W	1

Alarm Circuit

MC770P	3
MC724P	3
2N5551	1
Switches	4
Momentary switch	2
2 μF	1
10 μF	2
2.0K	2
Audio Trans	1
Speaker	1
Circuit board	1

SUMMARY OF PRICES

	Kit	Circuit Boards
12-Hour	$145.00	$13.50
12-Hour Less Seconds	125.00	13.50
24-Hour	145.00	13.50
24-Hour Less Seconds	125.00	13.50
Power Supply and Clock Generator (Separate)	35.00	3.00
Alarm Circuit	38.00	3.00
Walnut Cabinet		30.00
12-Hour Economy	$100.00	$12.50
12-Hour Economy Less Seconds	95.00	
24-Hour Economy	100.00	12.50
24-Hour Economy Less Seconds	95.00	

Kit includes semiconductors IC's Power Transformer, etc. No resistors or capacitors
B5750—$6.50 ea. MC780P—$3.50 ea.
Order all above parts from Safford Electronics, Inc., 427 S. Benbow Rd., Greensboro, N.C. 27401

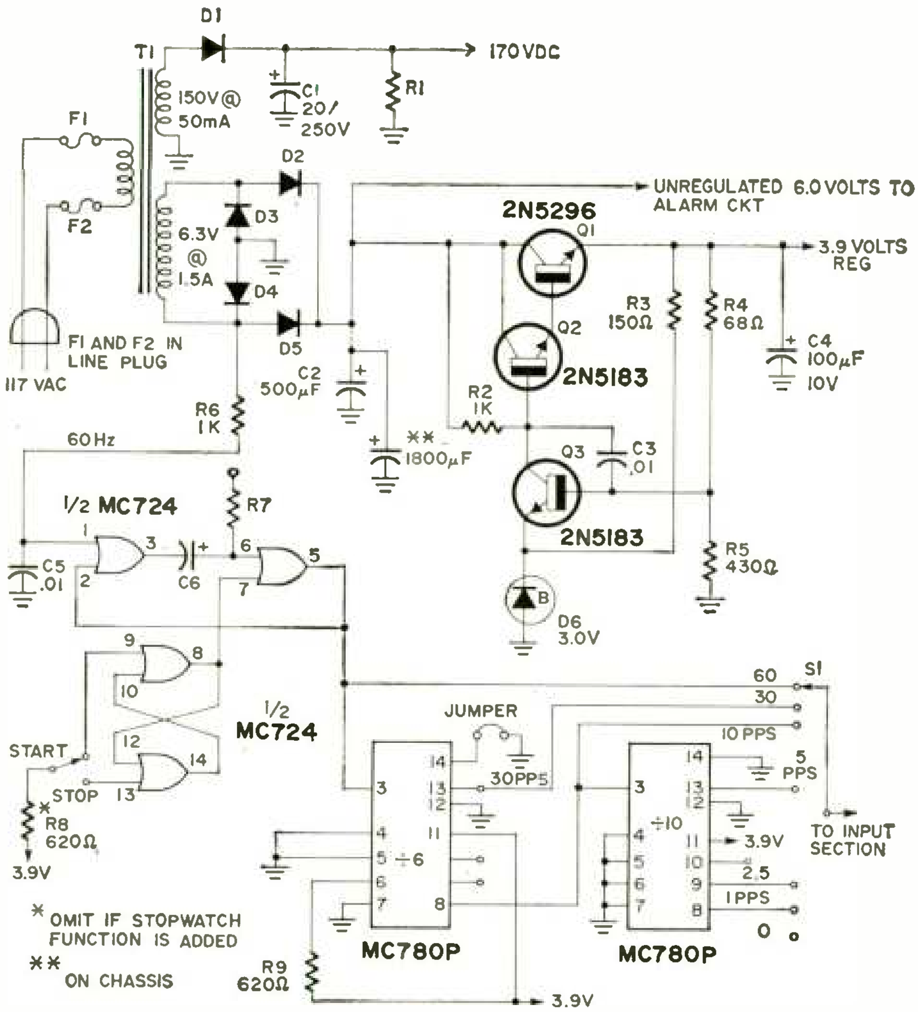
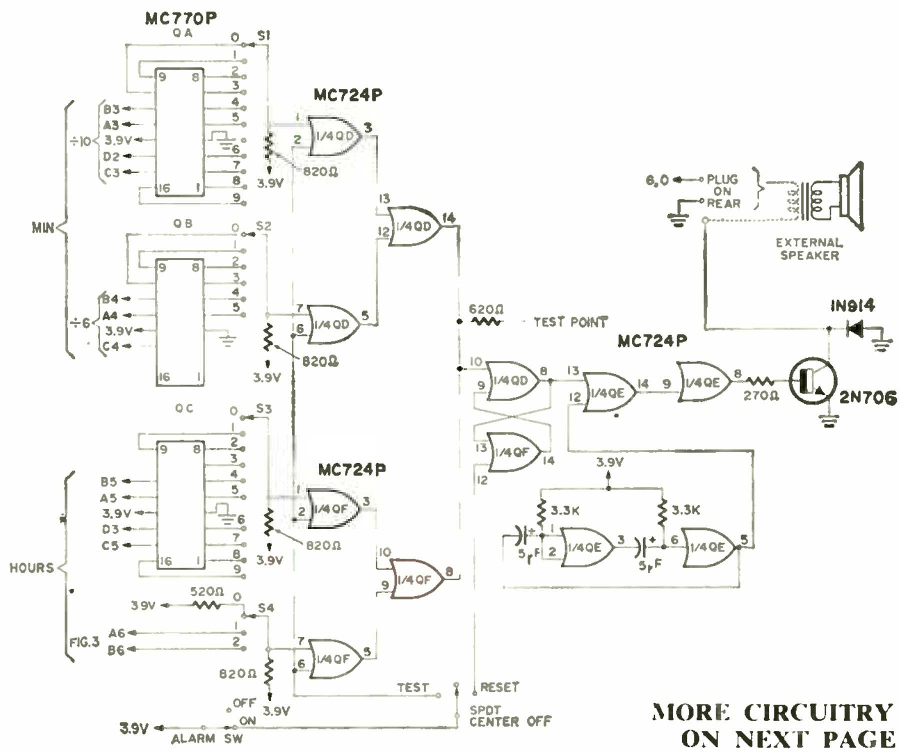
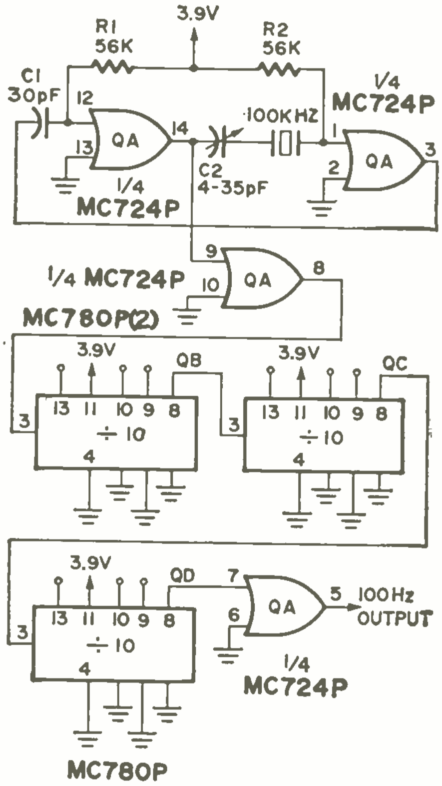


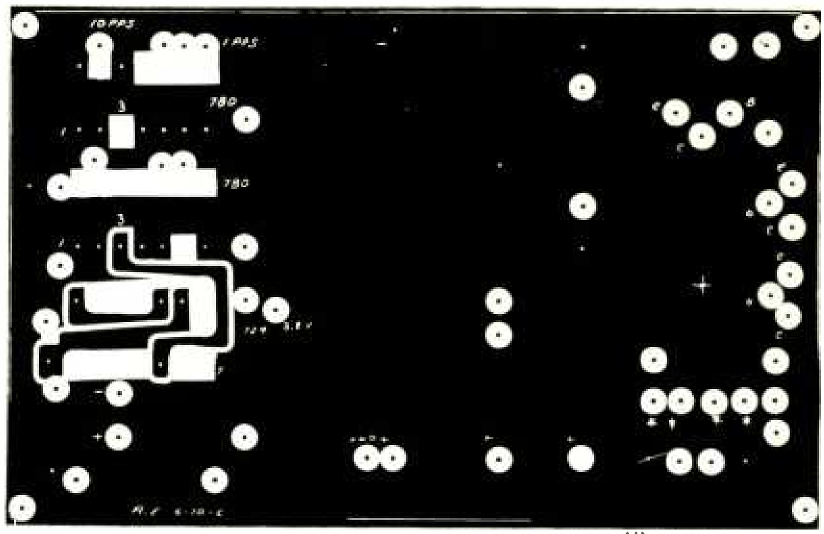
FIG. 4—POWER SUPPLY and clock-pulse generator section, which uses 60 Hz from ac line.

FIG. 5—ALARM CIRCUIT uses decoded hours and minutes signals fed through S1–S4 to trigger alarm.



MORE CIRCUITRY ON NEXT PAGE





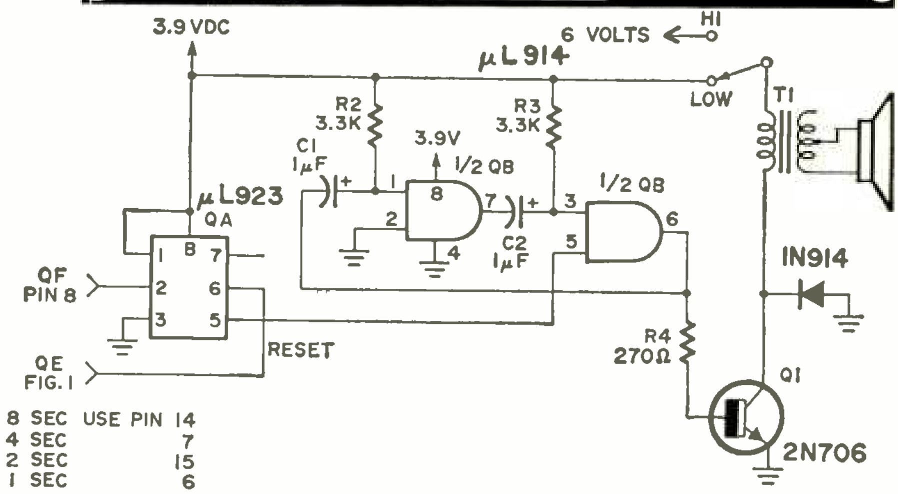
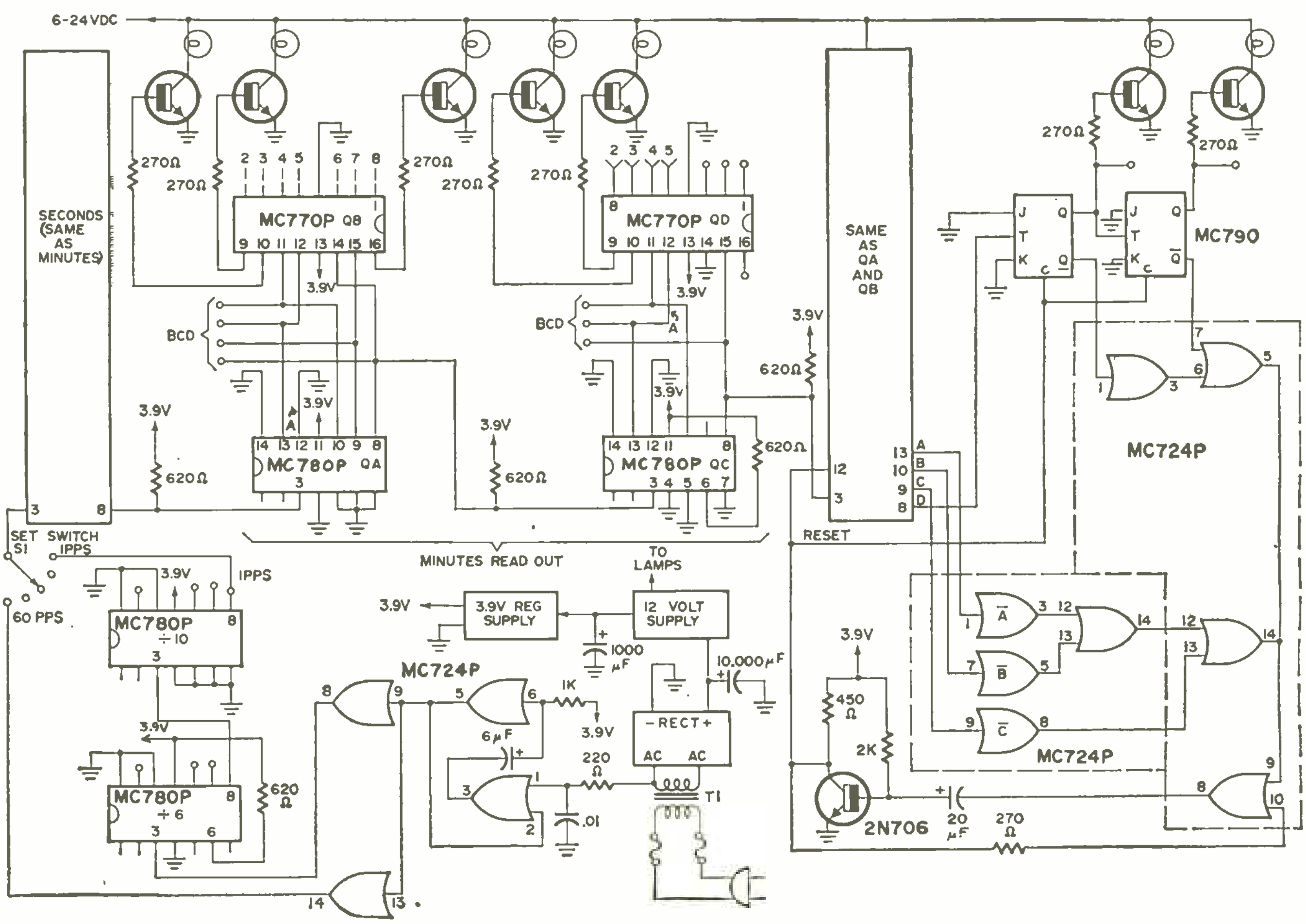
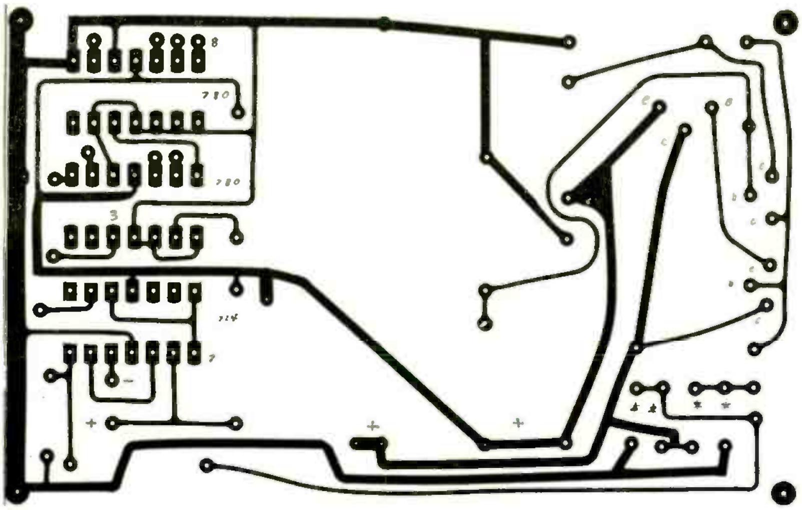
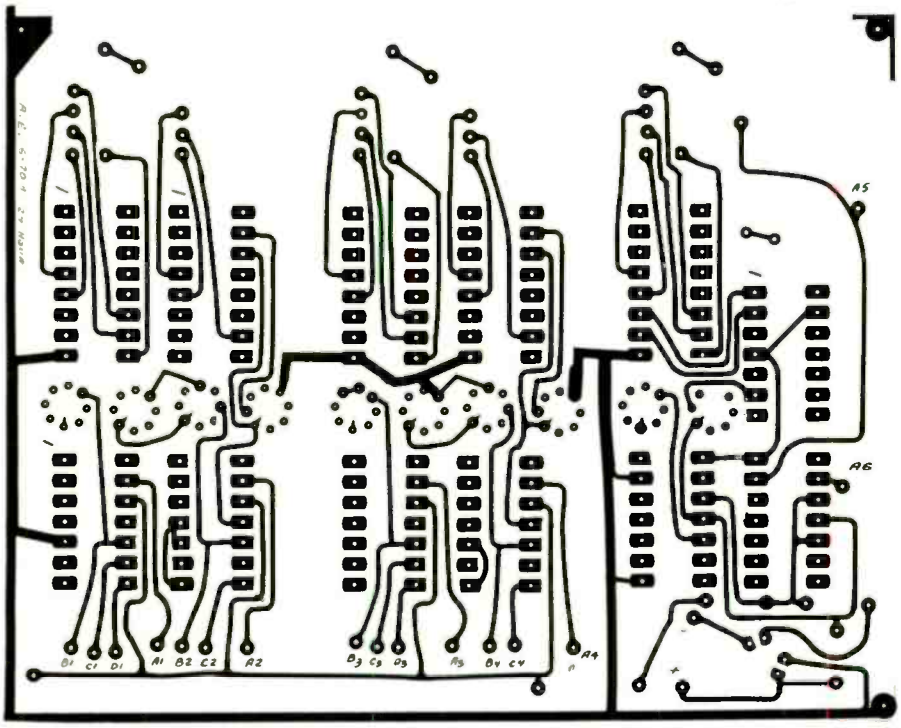
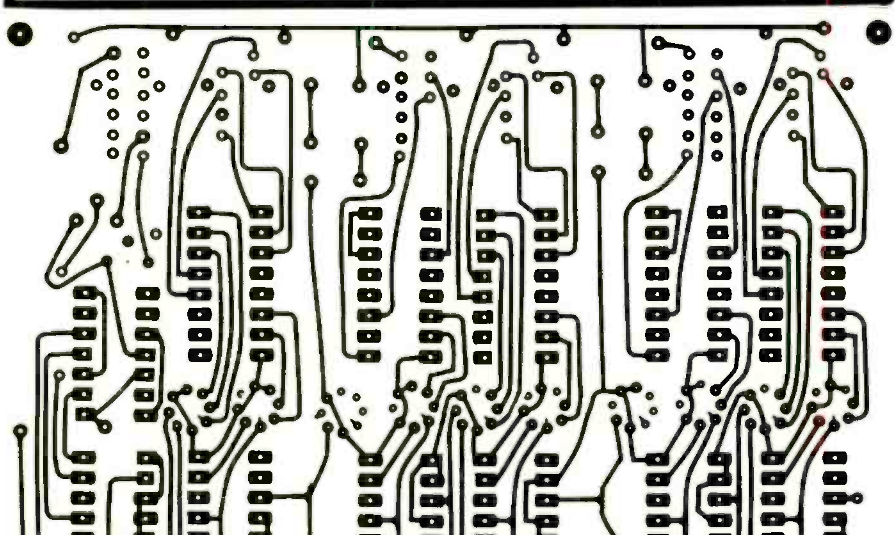


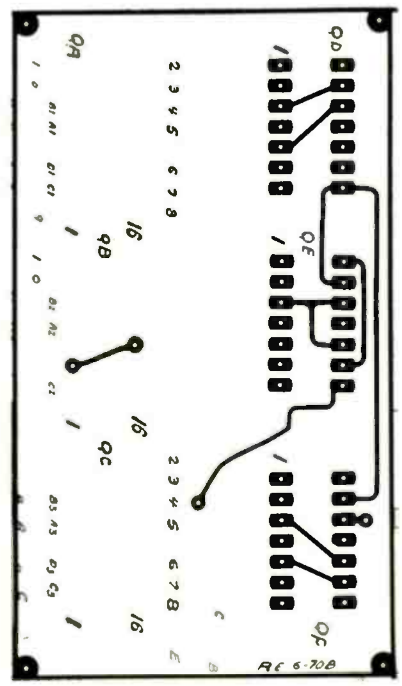
FIG. 6—100-kHz TIME-BASE GENERATOR provides greater clock accuracy (above). **FIG. 7—10-MINUTE TIMER** can be added to basic clock circuits (right). **FIG. 8—ECONOMY VERSION** of the 12- and 24-hour clocks is shown in the circuit below. **FOIL PATTERN** above is the top side of the double-sided board used for the power supply and clock-pulse generator.

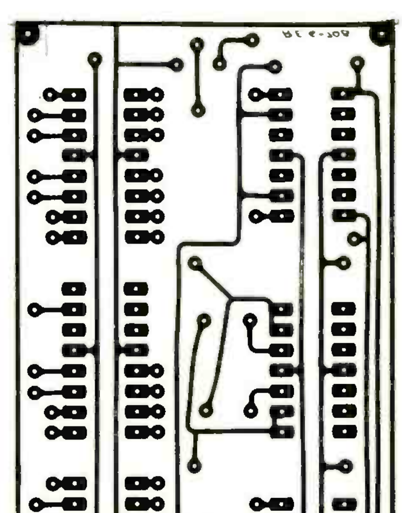












POWER SUPPLY and clock-pulse generator foil pattern on the left is for bottom side of double-sided board. Printed circuit patterns for 24-hour clock are below (left). The component side is shown above the interconnection pattern for the bottom of the double-sided board. Directly below are patterns for the alarm circuit. The component side is on top and the bottom side of the board is below. All patterns are actual size. Diagrams for parts locations cannot be shown until next month due to space limitations.

FOR NEW RECHARGEABLE CELLS

Universal Manganese-

Fully charges manganese-alkaline batteries in 16 to 20 hours.

by H. R. MALLORY*

BATTERY CHARGERS DESIGNED SPECIFIcally to recharge alkaline batteries properly may handle only two or four individual cells of the three sizes in any pair combination—four D's, two C's and two AA's, or two D's, etc. Chargers may *not* charge three, five or more cells, and require 30–36 hours for a full recharge.

This article presents a charger designed to charge rechargeable manganese alkaline batteries in 16–20 hours. Parts are readily available and add up to less than $20. This universal charger will accommodate batteries of 1–10 series cells of the three available sizes: D, C and AA (penlight). The charger is adjusted for a specific battery by setting the number of cells on one switch and the cell size on another switch. The charger is both voltage-limiting for the number of cells and current-limiting for the size of the cell.

How the circuit works

Referring to Fig. 1, the ac power-line input is reduced by T1 to 25.2 volts, rectified by D1 and passed on to the battery by series-pass or regulator transistor Q1. This transistor is insulated from, and heat-sinked to, the chassis. Cell-size resistors R8, R9 and R10 are also in series with the battery. Their function will be described later.

The voltage-limiting network consists of 20-volt Zener diode D2, resistor R1 (or 1813 bulb), variable resistor R2 and S2, which is attached to voltage divider R3 (10 resistors). Resistors R4 and R5, in parallel with single-cell resistor R3, compensate the single-cell position of R3 for the base-emitter drop of Q4.

Potentiometer R2 is used to adjust the network for 17.0–17.5 volts in the 10-cell position. Darlington-connected transistor Q2 amplifies the base-current drive requirements of Q1, and because of R7 would normally bias Q1 to saturation. Voltage-limiting transistor Q4 is always in saturation and limits the biasing of Q1, and consequently, the output voltage to whatever voltage (less the emitter–base drop) its emitter is receiving from NUMBER OF CELLS switch S2.

The base of Q4 is connected to the positive terminal of the battery through R12, so it is always sensing the battery voltage or dc output voltage of the charger when it is in operation.

The current-limiting network consists of CELL SIZE switch S3, connected to cell-size resistor R8, R9 or R10 and current-limiting transistor Q3. With a fully charged battery, whose voltage is approximately equivalent to the voltage set on S2, this network will have little or no effect on the biasing of Q1.

During that part of the charge cycle when the battery voltage is substantially lower than the voltage set on S2, the current flowing into the battery through one of the cell-size resistors (R8, R9 or R10) develops a voltage which forward-biases Q3. As Q3 conducts, it takes over control of biasing Q1 from Q4, thereby limiting the current of the charge as determined by S3's setting.

PARTS LIST

C1—2-section, 1,000μF, 15V electrolytic capacitor (Mallory WP200.1B or equiv)
C2—1,000-μF, 1V electrolytic capacitor (Mallory MTA1000F1 or equiv)
Resistors ½W, 10% unless noted
R1—100-ohm, 1W resistor (or No. 1813 bulb)
R2—100-ohm linear potentiometer (Mallory MR100T or equiv)
R3, R11—22-ohm resistors, 5% (10 required **for R3)**
R4—39 ohms
R5—180 ohms
R6—470 ohms
R7—6800 ohms
R8—2 ohms (Mallory 3AE2 wirewound)
R9—5 ohms (Mallory 3AE5 wirewound)
R10—15 ohms (Mallory 3AE15 wirewound)
R12—100 ohms
Semiconductors
D1—silicon rectifier (Mallory A50)
D2—20V Zener diode, 10% (Mallory ZA20A or equiv)
Q1—2N5035 (RCA) or 40513 transistor
Q2, Q3, Q4—2N3704 (TI) (or equiv)
Other parts
S1—spst switch
S2—1-pole, 10-position shorting switch (Mallory 4M11111 or equiv)
S3—1-pole, 3-position nonshorting switch (Mallory 3243J or equiv)
T1—25.2V, 1A transformer (Chicago Stancor P6469 or equiv)
MISC—6 x 2 x 4-inch chassis, pilot lamp, ac cord, knobs

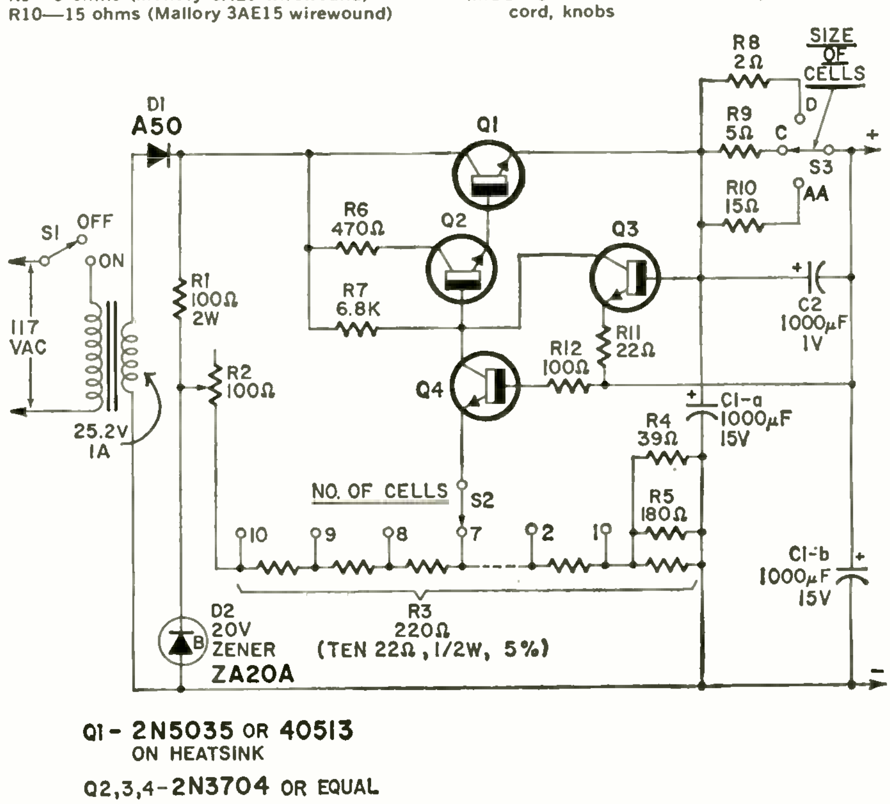


FIG. 1—SWITCH S3 SETS CURRENT-LIMITING action, while S2 sets voltage on cells.

*Manager, Battery-Powered Equipment Laboratory, Mallory Battery Co.

Alkaline Battery Charger

Takes 1 to 10-cell batteries . . . voltage and current limiting

Electrolytic capacitors C1 and C2 provide proper circuit filtering so that the voltage- and current-limiting action covers the voltage range of 1–10 cells and the three cell sizes. The voltage–current characteristics of this charger are plotted for one cell and 10 cells in Fig. 2.

For this 16–20-hour overnight charger, the charger voltage is limited to 1.70–1.75 volts per cell and the charge current is limited to approximately 160 mA for the D cell, 80 mA for the C cell and 27 mA for the AA penlight cell.

Assembly and use

The underside of the charger is shown in the photos. Transistor Q1 is heat-sinked to, and insulated from, the chassis by bolting it to the back of the chassis. Transistors Q2, Q3 and Q4 and their associated resistors are connected to the unused terminals of S1. This can be done only if S1 is a *nonshorting* type. One of the mounting ears of R2 is used to anchor this part to the pilot-light socket by soldering. Capacitor C1 is insulated from the chassis with a bakelite mounting plate.

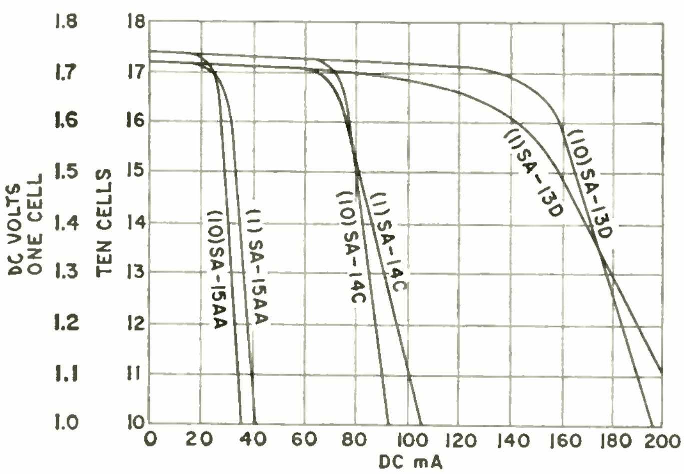
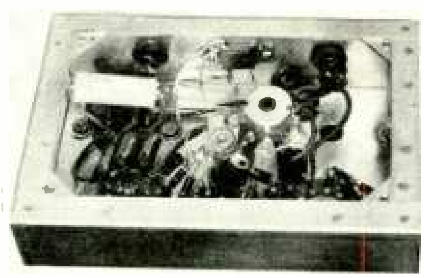
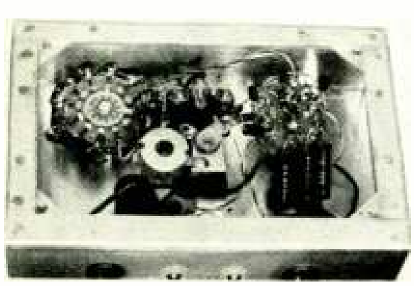


FIG. 2—CHARGER'S voltage-current characteristics for various batteries is shown for 1 and 10 cells.



TOP VIEW OF CHASSIS shows layout of switches, C1 and T1 on the prototype.



BOTTOM VIEW (above) shows positioning of Q1 on chassis back for good heatsinking.

SWITCH S1 is used to mount Q2–Q4. S2 has 10 resistors for R10 (view on left).

After the charger has been assembled, place S2 in the 10-cell position, S3 in D position, and connect an accurate dc voltmeter to the output leads. Potentiometer R2 is adjusted slowly until a voltage of 17.2 to 17.3 is obtained. The charger is turned off after each test operation, and the voltage at the various S2 positions is checked on the voltmeter. The voltages should be approximate multiples of 1.70–1.75 volts per cell.

Substitute a good partially discharged battery of either D- or C-size cells for the voltmeter. With S2 set for the proper number of cells in the battery, the current-limiting action can be checked with an accurate dc milliammeter in series with one of the battery leads. The current should be within 20–40 mA in the AA position, 60–100 mA in the C position and 120–200 mA in the D position. If the above performance is not obtained, recheck the wiring and the value of all components, especially the connections to all transistors.

Although the circuit is short-circuit-proof, to protect the transistors from abnormal current surges, make connections to the battery and adjust both switches with the charger turned off. The charger will fully charge any rechargeable manganese alkaline battery in 16–20 hours and will protect the battery from overcharge. Remove the battery from the charger when the charge cycle is completed since there is an approximately 60-mA discharge path through R12, Q4 and R3.

To obtain maximum battery cycle life, do not overly discharge the battery. Remove the battery from the load and charge it when the battery voltage approaches 1.1 volts per cell, or when the flashlight starts to dim, the motor starts to slow down, etc. Properly used and charged, rechargeable manganese alkaline batteries will provide many useful discharge–charge cycles. **R-E**

DIGITAL CLOCK UPDATE

by LINDSEY G. RIDDLE*

SINCE THE ARTICLE BY ED LORD ON IC DIgital clocks was published in the September, 1969, issue of RADIO-ELECTRONICS I have been building and rebuilding from his idea. This article passes on some of my experience and additions that have been made to his construction article.

Much effort has been made to simplify the construction and lessen the chances of error. Two printed circuit boards have been designed to accomplish this. On one, the leads from the readout drivers (SN7441N) are terminated with numbers so they can be easily connected to the proper leads of any readout tubes. This gives flexibility in designing and mounting the display tubes in different mechanical setups. The tubes come in sizes ranging from ½" to 2".

The readouts are mounted on the other board. The tubes used are the National or Burroughs 5750. If you use different readout tubes this section of the board will have to be modified. Readout tubes are beginning to show up in the bargain ads, so with this type of arrangement it will be possible to use any type that draws about 3 mA. The seven-segment type will not work in this circuit, as they require a different switching configuration to make the individual numbers. Nixie-type readouts require only one switch to close to make any number.

The one big change that has been made is that the pulses are derived from a 10-MHz crystal instead of the 60-Hz line. A digital clock operating from a line source is not more accurate than any electric clock and has some disadvantages such as higher cost, difficulty of setting, and most seriously the complete loss of all time with even the slightest interruption of power. This problem can be overcome by using rechargeable batteries to operate the clock, and a charger floating to keep the batteries charged. The unit draws a total of approximately 500 mA at 5 volts for the counters and the clock, and approximately 20 mA at 170 volts for the readout. It is not necessary to furnish 170 volts on the readout as any power interruption would not change the timing of the clock. The tubes would not light during the interruption.

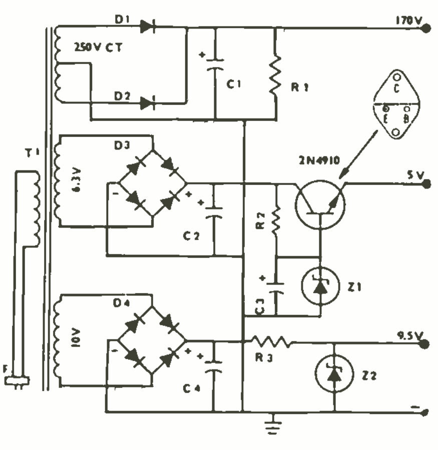
It would be an easy matter to construct an inverter from 5 volts to 170 volts if one wanted the readouts on during power interruptions. The International Crystal OE-10 has an accuracy of .0005%. If one wanted even more accuracy a type OE-30 of .0002% is available at a higher price. A chart comes with each crystal showing the change of frequency versus temperature changes. For example, from +60° to −10° Centigrade the frequency changes from seven cycles low to nine cycles high. At normal room temperatures the fre-

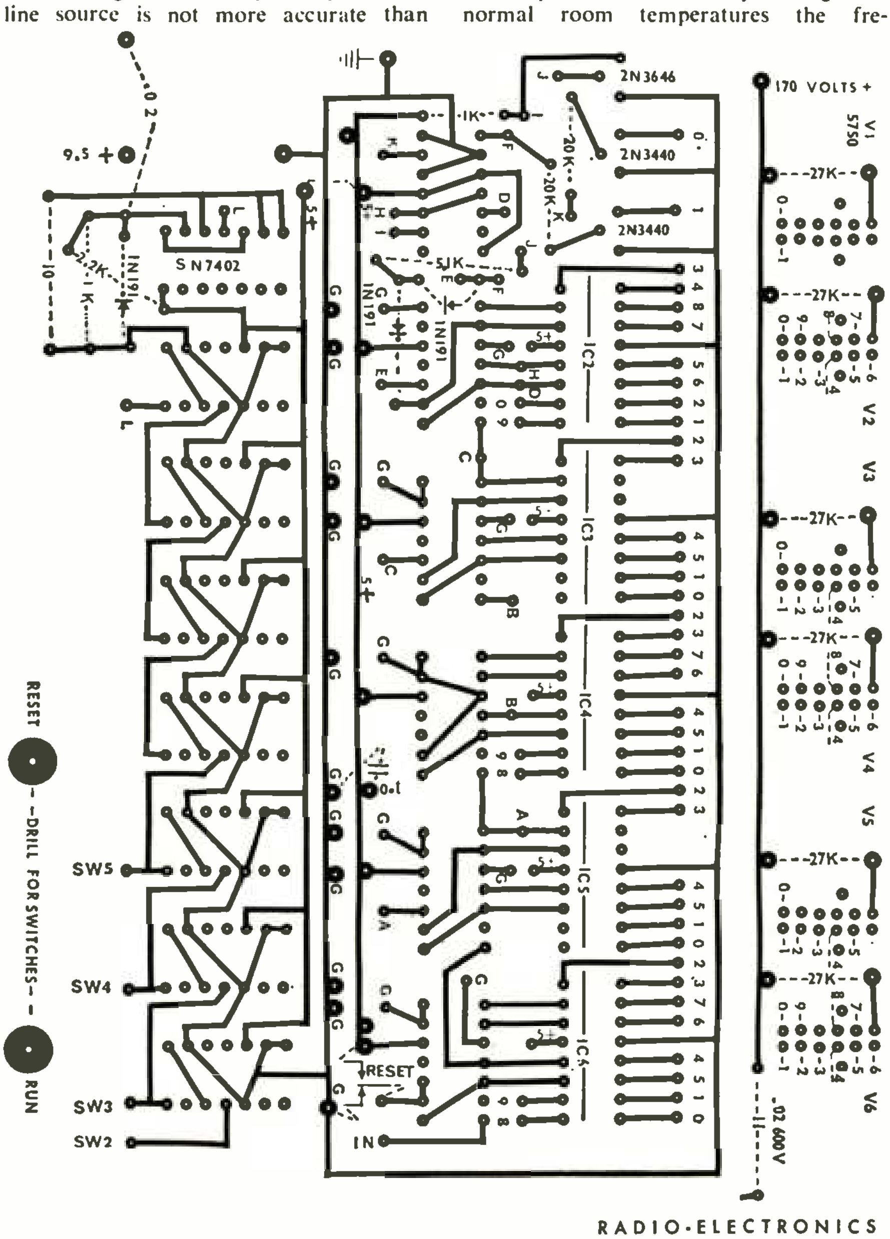
*President Engineering, WDSU-TV, New Orleans, La. 70130.

PARTS LIST
Power Supply

C1—20-μF, 250V electrolytic capacitor
C2—3,000-μF, 15V electrolytic capacitor
C3—200-μF, 6V electrolytic capacitor
C4—250-μF, 15V electrolytic capacitor
R1—470,000-ohm, 1W resistor
R2, R3—330-ohm, ½W resistor
D1, D2—1-amp, 600V diode (Motorola 1N4005)
D3—1.5-amp, 100V rectifier (Motorola FW100 or equiv)
D4—1-amp, 50V rectifier (Motorola HEP175 or equiv)
1—2N4910 transistor (with Motorola mounting kit MK25)
Z1—5.6-volt, 1W Zener diode
Z2—9.1-volt, 1W Zener diode (HEP104)
T1—transformer (Stancor PS8416, see text)
MISC—Elmenco fuse plug, 1-amp fuse (2), 6-lug terminal strip, No. 32 enameled wire, line cord

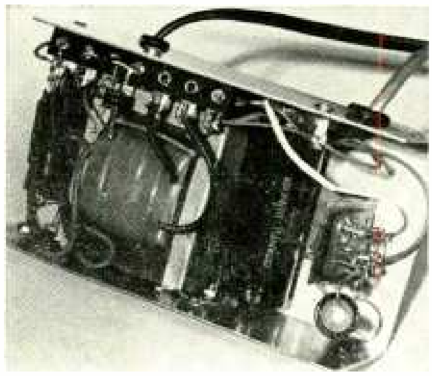
TWO-SECTION PC BOARD is actual size. Power supply can be built into Mini-box.





PARTS LIST
Clock Unit

1—0.1-µF, 100V capacitor
1—.02-µF, 100V capacitor
1—.02-µF, 600V capacitor
All resistors ½W, 10%
1—5,100 ohms
2—20,000 ohms
2—1,000 ohms
1—10,000 ohms
1—2,200 ohms
6—27,000 ohms
5—SN7441N integrated circuit. National Semiconductor (NS) or Texas Instruments
12—SN7490N (NS or TI)
1—SN7470N (TI)
1—7402N (TI)
2—40346 (RCA) or 2N3440 transistor
1—2N3646 transistor
3—1N191 diode
1—10-MHz crystal (International OE-10)
6—Nixie tubes with sockets (Burroughs) or National 5750. Or Raytheon socket No. CK1829 and tube CK8754
1—1-to-5-position switch (Alco MRA-1-10S)
1—spdt miniature pushbutton switch (Littel Switch No. 203 or Switchcraft 953SW)
MISC—12 14-pin in-line IC sockets, 5 16-pin in-line IC sockets, 3 transistor sockets
Note: National Semiconductor IC's can be purchased from Hall-Mark Electronics Corp., 8000 Westglen, P.O. Box 36739, Houston, Texas 77042 or Sterling Electronics, 537 S. Claiborne, New Orleans, La. Texas Instrument IC's from Allied Electronics, 100 N. Western Ave., Chicago, Ill. 60680 or Newark Electronics Corp., 500 N. Pulaski Road, Chicago, Ill. 60624. For crystal prices write International Crystal Mfg. Co., Inc., 10 North Lee, Oklahoma City, Okla. 73102.
Note: A kit (minus the 10-MHz crystal) is available from Stafford Electronics, 427 Benbow Rd., Greensboro, N. C. 27401 for $245. Circuit board $9.75. Power supply board $2.50.



'BUILT-IN' line-cord power supply (left). Above view shows neat layout using decal.

quency varies very little. To calculate the accuracy, figure that it takes 10,000,000 cycles to produce 1 pulse per second. Then if the crystal were off one way by one cycle all the time, it would take 10,000,000 seconds or approximately four months for the time to be off one second.

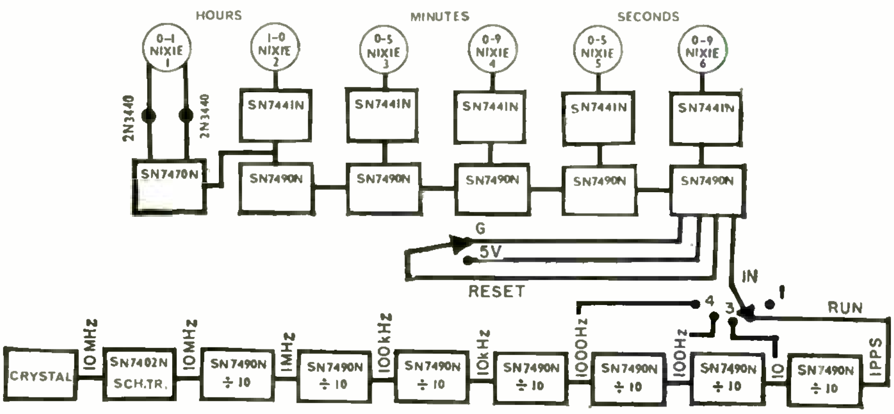
The purpose of the RUN switch is to enable the clock to be speeded up for easy setting. Changing the switch from #2 position or RUN to #3 position will make the unit count ten times as fast as normal, etc. Mechanical switches do not make a definite contact when first closed and produce spikes or transients. These transients cause the readouts to advance and give false readings. To overcome this, a reset button is included. The clock should be advanced a few seconds ahead of the actual time and then stopped, using switch position #1. There is no pulse on this position so the clock stops.

A few seconds before the actual time has arrived the reset button should be pressed and held down. This will cause the first "Seconds" readout to reset to zero, and the clock will not run when the reset is depressed. The switch is moved to #2 or RUN, and as the exact time arrives the reset button is released, permitting the clock to run.

Because of its accuracy, WWV should be used for the setting. They broadcast twenty-four hours daily on 2.5, 5, 10, 15, and 20 MHz, giving the exact time each five minutes, plus pulses each second. With the clock operating in the same room as the WWV receiver it is easy to hear the crystal beating against WWV. It is possible to get them exactly together by slowly adjusting the padder capacitor on the crystal oscillator. Before the clock is set the ac plug should be plugged and unplugged until the readouts are changing exactly with WWV seconds. If this is not done it will be impossible to get the clock counting exactly with WWV.

The 10-MHz crystal puts out a sine wave. This sine wave must be squared some before it will trigger the first decade counter. This is accomplished by using an IC (SN7402) connected in a Schmitt trigger circuit. The SN7409N

(*continued on page 68*)



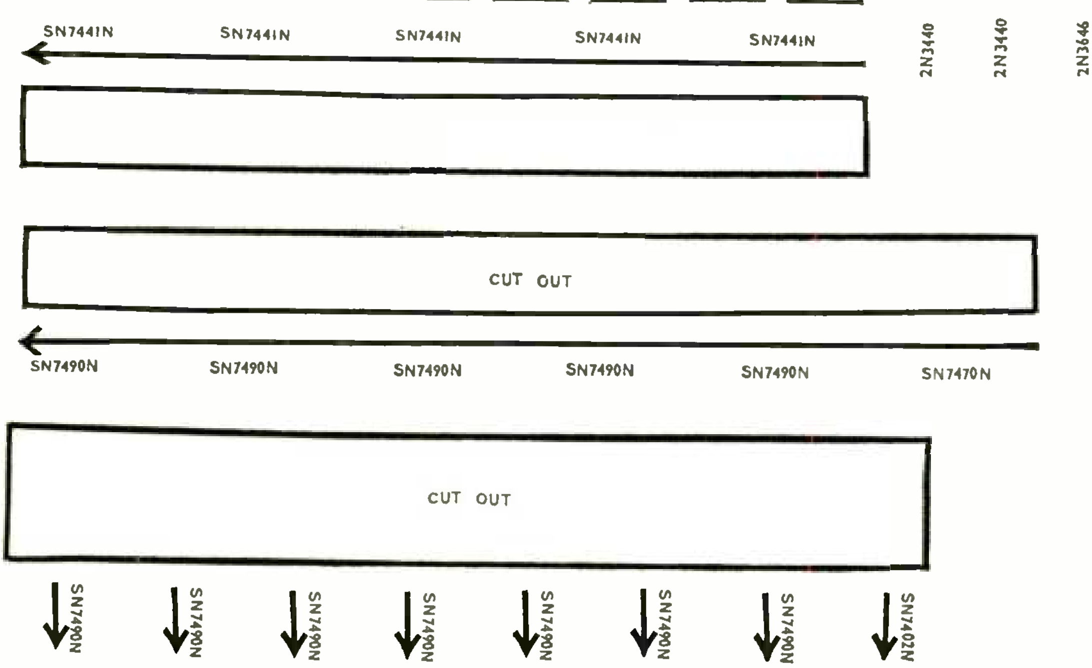
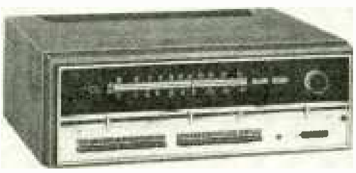


DIAGRAM above shows divider and counter IC's used. The cut-out decal at left is placed on IC-side of the PC board to aid in the installation of components.

NEW PRODUCTS

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card on page 77 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

AM-FM/FM STEREO RECEIVER KIT, *AR-29,* features all solid-state circuitry with 65 transistors, 42 diodes, and 4 IC's. Frequency response: from 5 to 30,000 Hz with less than 0.25% harmonic & IM distortion at any power level. Regulated power supply, Output transistors protected against short-circuit conditions by dissipation-limiting circuit. Prebuilt, prealigned FET FM tuner has 1.8 μV sensitivity. Computer-designed, 9-



pole L-C filter gives bandpass selectivity of 70 dB or better, and eliminates i.f. alignment. Features plug-in circuit boards. Simplifies checking of circuits during assembly and after without extensive dismantling. Built-in test circuitry (probes & meter) permit checks at any time without external test equipment. Button activates "noise muters" to eliminate on-station FM background noise and noise bursts that occur between stations. Stereo headphone jack provided on front panel. $285.00 Heath Co., Benton Harbor, Mich. 49022.

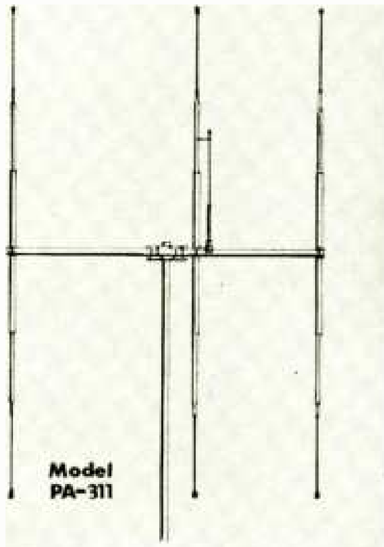
Circle 31 on reader service card

MINIATURE WELDER, three sapphire welding tips and torch. Torch can solder wires of 1 mil or less up to 16-gauge steel. Joins steel, platinum, gold, silver, copper,

and other metals. Flame up to 6300°F. at 2 to 4 psi, rate of gas is .23 to 2.54 cfh. Tips in 5 sizes.—Instrument Div. Tescom Corp. 2633 S.E. 4th St. Minneapolis, Minn.

Circle 32 on reader service card

THREE-ELEMENT BEAM ANTENNA for CB, the *Paragon Beam, model PA-311,* features 3-piece boom and balanced elements with swaged tubing to reduce



vibration in the wind. Improved gamma matching system includes molded gamma base and connector for greater convenience and durability. $46.65. Mosley Electronics, Inc., Bridgeton, Mo.

Circle 33 on reader service card

MULTIMETER, *Model TE-235,* taut-band meter suspension. Pushbutton range and function switches. Expanded scale meter with built-in mirror for parallax correction. Sensitivity: 30K ohms/volt. Ranges: dcV—0–1, 2.5, 10,

50, 250, 1000; acV—0–2.5, 10, 50, 250. DB: −10 to +36. Resistance: 0–5,000, 50K, 500K ohms, 5 meg. Dc current: 0–50 μA, 100 mA, 250 mA, 500 mA, 10 A. Size: 8½" x 5⅝ x 2$^{13}/_{16}$". Batteries and test leads included. $39.98. Olson Electronics, Inc., Akron, Ohio.

Circle 34 on reader service card

KNIGHT-KIT DEPTH METER, *model KG-711,* and fish locator has electronic transducer that attaches to transom, side or bottom of boat. Sends down cone of ultrasonic waves which return as echoes appearing as flashes of light on meter dial. Operates on either 8 "C" batteries or from boat battery. Range up to 200′ on hard bot-

toms and up to 100′ on soft bottoms. Frequency: 200 kHz. Rate: 1440 soundings per minute. Scope: 5 x 5½ x 5". Transducer: 6¼ x 2½". Brass and plastic construction. Plastic sun shade, brass mounting bracket for transducer, gimbal mounting bracket for scope, cables and instructions. $69.95. Allied Radio Corp., Chicago, Ill.

Circle 35 on reader service card

BATTERY CHARGER, *Model BC-16* recharges alkaline rechargable batteries. Accepts pairs of AA, C and/or D cells only. Uses 120 Vac. $8.95—RCA Electronic Components, Commercial Engineering, Harrison, New Jersey.

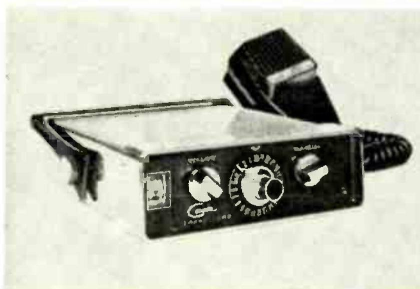
Circle 36 on reader service card

SOLID STATE OSCILLOSCOPE, *LBO-501,* 5" scope with bandwidth of dc to 10 MHz, triggered sweep range from 0.2 μsec/cm to over 0.2 sec/cm, calibrated vertical input, sharp rise-time calibration square waves, calibrated time base, special sweep positions for viewing horizontal and vertical TV, vertical sen-

sitivity of 20 mV p-p/cm. Tilt stand for easier viewing. Uses semiconductors, high voltage power supply and dc coupling. $339.50. **Leader Instruments,** Long Island City, N.Y.

Circle 37 on reader service card

SMALLEST CB RADIO, *Traveller II,* features illuminated S-meter, greater sensitivity, public-address capability with volume control, greater image rejection, and plug-in dynamic microphone, true automatic i.f. noise blanker which reduces ignition noise from strong incoming sig-



nals. Built-in noise limiter reduces ignition noise during reception of weak signals. Full talk power, instant operation, minimal battery drain using only 200 mA. Safety Circuit guards against antenna mismatch, incorrect polarity and overload. $139.95. Mr. Steve Kappel, Sales Mgr., **Courier Communications,** 100 Hoffman Place, Hillside, N. J. 07205.

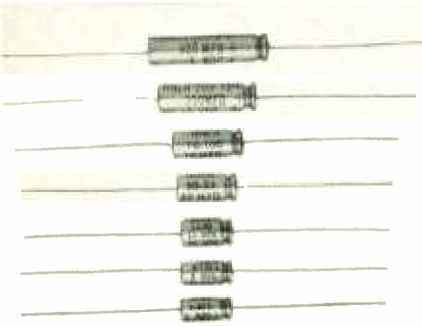
Circle 38 on reader service card

NEW LINE OF MIKES includes cardioid and omni-directional models. Both dynamic and crystal types. Available with variable impedance which can be switched from high to low. Equipped

with built-in volume control. Some have meshed wind screens to suppress feedback "pop," booming and breathing noise. **Fanon Electronics,** 100 Hoffman Place, Hillside, N. J. 07205.

Circle 39 on reader service card

MINIATURE ELECTROLYTIC CAPACITOR, Type *HNLH,* all-welded, polarized, and etched foil construction. Temperature range —80°C to +110°C. Voltages from 3 to 150 V. For applications in communications equipment, computers, telemetry, timing circuits,



and power supplies. All aluminum construction for minimum capacitor weight. Use where requirements include compactness, light weight, moderate cost, a high order of dependability, and high capacitance per unit volume.—CD Electronics, 50 Paris St. Newark, N.J. 07101.

Circle 40 on reader service card

"COMPUT-A-TUTOR" 71-259. Family game of skill and chance centered around the world of electronic data pro-

cessing. Simple arithmetic required. Included are elementary and advanced stages of play. $6.95—Edmund Scientific Co. 380 Edscorp Bldg. Barrington, New Jersey.

Circle 41 on reader service card

MUSIC AMPLIFIER, *UPB 10T.* Low distortion, high or low mike input, separate mike and program level controls, tone control. 25 V and 70 V constant voltage output plus direct output, for paging, background music, business systems. University Sound Dept. 72-19 Box 26105 Oklahoma City, Oklahoma 73126.

Circle 42 on reader service card

MULTIMETER, *model 2795,* solid state, has 68 switch-selectable functions for measuring 13 ac and dc voltage ranges as low as 1 mV full scale, 14 ac and dc current ranges as low as 1 μA full scale, 6 low power (IC compatible) resistance ranges (.9 mW dissipation), 6 capacitance ranges from 1 μF to 100 μF, 2 temperature ranges, plus 12 output ranges (dB). Temperature compensated over range of 0° to 50°C, with rated accuracy of ±1.0% for both ac and dc. Battery operated, transistor amplifier and MOSFET chopper. Features 10 megohm

Circle 66 on reader service card

input impedance on ac and dc ranges above 10 volts. Voltage drop of 7 mV at 10μA. Overload protected on all ranges through a reset-type front panel circuit breaker. Varistor prevents meter movement overloads. Taut-band suspension movement. Has anti-parallax mirror. Single linear scale for all ac/dc voltage and current measurements. Complete with test leads, batteries and instruction manual, $230.00. **Simpson Electric Co.**, 5200 W. Kinzie St., Chicago, Ill. 60644.

Circle 43 on reader service card

Circle 67 on reader service card

CHEMICAL TOOLS include *Blue Stuff, Blue Shower, Tape and Head Spray, Anti-Static Record Spray, Lemon Oil, Plastic Polish & Cleaner,* plus many others. All

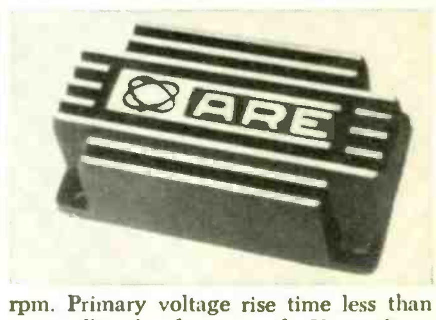
are especially designed for use by the service technician and cover all of his chemical needs.—**Tech Spray**, P.O. Box 949, Amarillo, Tex. 79105

Circle 44 on reader service card

Write direct to the manufacturers for information on items listed below:

New address for Precision Tuner Service— Precision Tuner Service is adding a fifth tuner repair plant to its four established locations. With executive offices on the premises, the plant provides a large area for shipping and receiving, and half the floor space is designated for storage of spare tuners and parts to speed service. The new address is 5233 South Highway 37, Bloomington, Indiana.

CAPACITIVE DISCHARGE IGNITION, *Ramfire, model CD-21,* operates with stock coil and breaker point distributor. Increases plug and point life and delivers hotter spark across larger gap to racing speeds in excess of 10,000



rpm. Primary voltage rise time less than one millionth of a second. Uses silicon semiconductors. Offers anti-point bounce and secondary arcing protection. $49.95. **ARE, Inc.**, P. O. Box 9562, San Jose, Calif. 95117.

PROGRAMMED DOOR ALARM SYSTEM, *PDAS 450.* May be used in single-zone system with one or more detectors and alarm device or in elaborate multiple systems using remote annunciators, closed-circuit TV, etc. Features: disconnects any existing alarm system to enable legitimate entry, predetermines entry time. **Plessner Electronics Co.**, 81 Bloomingdale Rd., Hickeville, N. Y. 11801. **R-E**

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 79 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

CATALOG—*Number F-70, Chassis Punches and Knockout Punches.* Includes various tools for cutting holes in metal, rubber, plastic, etc. All punches use ordinary hand wrench. Geared toward amateurs and professional craftsmen, these tools save both time and labor.—**Greenlee Tool Co.**, 2136 12th St., Rockford, Ill. 61101

Circle 45 on reader service card

ELECTRONICS PARTS CATALOG—*No. N-71,* includes hundreds of products for engineers, technicians, and hobbyists. Lists capacitors (fixed and variable), chemicals, resistors and potentiometers, transformers, switches, lamps, fuse holders, test equipment, lab supplies, mikes, speakers, and many other most-wanted supplies. —**North American Electronics**, 1111 Seminary St., Rockford, Ill. 61108

Circle 46 on reader service card

PANEL METER CATALOG **No. D-70.** Twenty pages packed with panel meter data. 1½", 2½", 3½", 4½", 5½", 6½", 7½", & 8½" models are described. Special units, including edgewise meters, wattmeters, and suspension meters are also included.—**Triplett Corporation**, Bluffton, Ohio, 45817. **R-E**

Circle 47 on reader service card

COLOR TV CAMERAS
(continued from page 32)

is there once again, but this time working for all three primary colors. Another major difference: the Sony camera has a separate luminance pickup tube.

Some of the special features of the camera include ultra-compactness. The camera head weights 27½ pounds and horizontal resolution is stated as 450 lines at the center in the latest spec sheets. Overall resolution and edge resolution aren't stated, but in eyeball tests, the camera's picture looks good indeed.

Another compact entry, this one by Toshiba, is a featherweight at just 10 pounds (without the lens). Like the Sony, this camera has two pickup tubes—one for color and one for luminance. The camera's resolution is stated at 300 lines, and it is designed for the usual noncommercial TV categories. The camera head contains a built-in control unit and rf generator so monitor connection can be made directly via a standard color receiver's antenna terminals.

Other Japanese models

Panasonic's newest compact camera uses the standard three pickup tubes with an uncomplicated optical system. The tubes are 2/3-inch separate-mesh vidicons and the camera head weighs in at 28 pounds without the lens. Horizontal resolution is given at 400 lines (center of picture) and the rack-mountable control unit is minuscule as such units go. Again, this camera is primarily for CCTV and other less-than-broadcast critical performance.

Other cameras are vying for the low-price championship, but all have three pickup tubes. A Japanese entry distributed by GBC Closed Circuit TV Corporation is fairly compact and features fast setup time—eliminating one major drawback of the majority of TV cameras: hours of warmup time and setup adjustments.

It all adds up to one thing: a truly low-cost color

ANOTHER color camera illustrating trend toward lower cost and complexity is the VF-7001 by GBC.

camera priced for the hobbyist, experimenter and TV ham is still a couple of years away. Bottom of the line right now is about $5,000, but with developments coming as fast as they are, and the new two-tube Japanese format, two or three years may see color cameras breaking the thousand-dollar barrier. After that, prices will continue to tumble; someone will introduce a kit at $500 (less lens), stripped-down versions without sync boards and viewfinders will hit the market, and color will at last be here at a bargain price. But it's not here yet. Not quite. **R-E**

PORTABLE VTR'S
(continued from page 12)

needs of the pickup device (vidicon) and the viewfinder (CRT). Most cameras also mount the microphone; however, only wire connections are provided for the mike and all audio processing is accomplished in the shoulder pack.

Fig. 9 shows a simplified block diagram of the Sony DVC-2400. Output of the vidicon is amplified to about 2

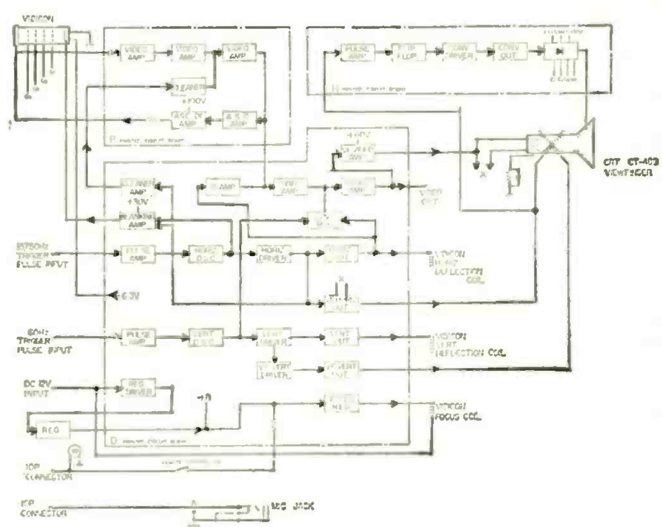


FIG. 9—SIMPLIFIED BLOCK DIAGRAM for the DVC-2400.

volts through a series of low-noise, wide-band amplifiers that also compensate for the frequency rolloff that occurs in the coupling from the vidicon to the first amplifier. Part of the output video is clamped and rectified in the automatic sensitivity control (ASC) detector to provide a dc voltage proportional to average white level. This dc voltage

(continued on page 71)

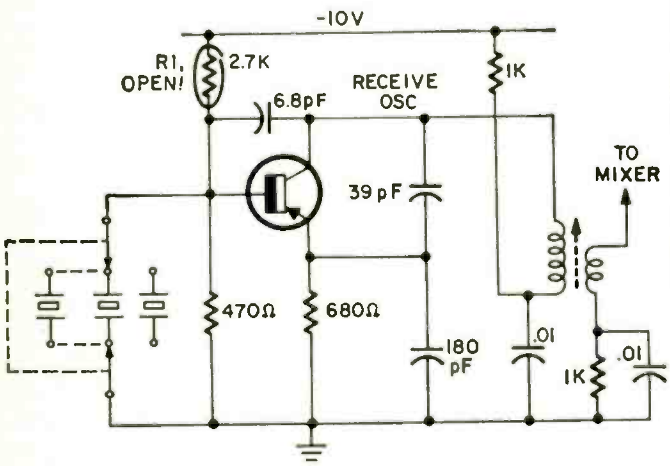
CB Troubleshooter's Casebook

Compiled by

Andrew J. Mueller*

Case 1: Radio does not receive. Transmits ok.

Common to: Johnson Messenger 100

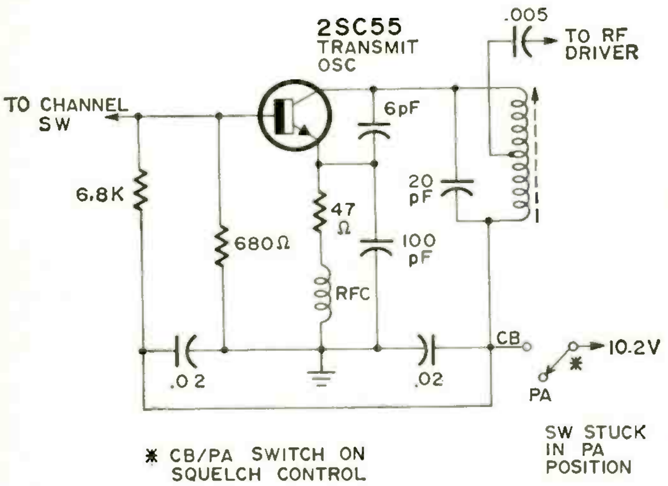


Remedy: Replace R1.

Reasoning: R1 is the bias resistor in the local receive oscillator. It has opened, preventing the oscillator from starting when the set is turned on. Replacement restores the radio to normal operation.

Case 2: Radio does not transmit. Receive is ok.

Common to: Lafayette HB-525A



Remedy: Replace the squelch control and switch.

Reasoning: The PA switch is on the rear of the SQUELCH control. The switch is defective and stuck open, and no voltage can reach the transmit oscillator. As this is all one part, the entire control must be replaced. R-E

*Service Manager, Tel-Air Communications, Inc., Pewaukee, Wis.

In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

Diddle Adjustments For Color

WE HAD A GE KC COLOR CHASSIS WITH some very unusual symptoms. Unusual at least according to the diagnosis made by another technician—namely, "bad power transformer." It had a bright picture, but the reds were weak. Greens and blues looked o.k., or not too bad anyhow. The color-bar pattern had a distinct weave in it. It was supposed to have had a past history of circuit-breaker trouble, too. But the wattmeter didn't show anything unusual—in fact, it was drawing a little less than the rated wattage.

Well, let's see. Take the easy one first. Ripple in the power supply? Yes, indeed. The scope showed about 15–18 volts p–p ripple on the 400-volt B+ line. Hmmm. While I was at it, I probed around the CRT grids. The rocker patterns there were very badly smeared. I couldn't even see the vertical lines of the color bars. The screen showed the same kind of smearing. The Vectorscope pattern had to be seen to be believed. It looked like a dwarf chrysanthemum with the Dutch Elm disease or something equally gruesome.

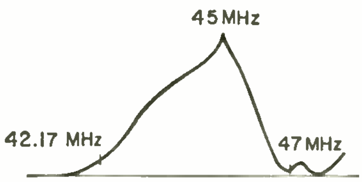
A scope pattern also showed a very plain 60-Hz bending in the video waveforms. So, back to the power supply. Bridging filter capacitors didn't help a lot. I remembered a hint I'd made a note of quite a while back. Why not check for an *open* rectifier in the full-wave bridge circuit used here?

Checking the rectifiers showed that this was indeed the case. The clod who had "worked" on this first had replaced a rectifier, but forgot one minor detail: one end wasn't soldered. This cleaned up the hum problem, and I got back the 50 volts I'd lost in my 400 volts B+.

The color bars *still* looked funny. Reds still weak, smearing still present. We had dc voltages all around the demodulators, and the color difference amplifiers, etc. were balanced. A Vectorscope pattern looked quite a bit healthier, but was still a little bug-eaten on the red side. The petals were cleaner, though, since the ripple had been removed.

Well, if he makes bad solder joints, maybe he's also a "diddle stick artist". Using the Vectorscope pattern to touch up the alignment of the demodulator transformers helped a lot. My flower now shaped up a lot better, but it was too small. Did he get the bandpass transformers, too? He did. Touching up the bandpass transformers for maximum length (amplitude) of the petals brought the color up on the CRT.

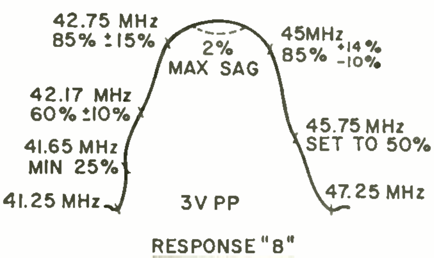
Now, there was only one little thing left. The whole thing, color-bar pattern or color picture, had that indefinable "I-just-don't-look-quite-right" look to it. So, I hooked up the sweep generator and scope and took a look at the i.f. alignment curve. I knew he couldn't keep his cotton-pickin' hands out of the i.f., too. The curve looked something like Fig. 1-a.



a

Notice the sharp peak at 45 MHz, and the low amplitude of the color subcarrier at 42.17 MHz. This was making the color a little bit weak!

Touching up the appropriate i.f. transformers helped the shape of the curve a lot, but I couldn't get the color subcarrier marker up off the floor. After a good bit of head scratching, I uncovered the reason. The 41.25-MHz sound trap does *not* belong over in that part of the curve! If it's mistuned that much, it will suck the color carrier right out of the curve. Moving it back where it belongs left the curve looking more like Fig. 1-b.



b

Correct tuning of this trap will do a lot to keep the worms out of the color in an otherwise fairly good color picture. If the set tunes all right, but the color drops out as soon as you tune it out of the worms, look at this sound trap. If it is only a tiny bit mistuned, it can get over into the 42-MHz region and chew the heck out of the color carrier.

A careful, scientific diddler *can* make this adjustment in the home with the well-calibrated eyeball, *if* the only trouble symptom is too many worms in the color areas. **R-E**

Service Clinic

by JACK DARR
SERVICE EDITOR

Top Droop

I've got a decided curve in the horizontal lines at the top of the screen in a Zenith 20X1C38 color TV chassis. Rolling the blanking bar down the picture shows something like the sketch. The bottom part is fairly straight.—J. B., Flint, Mich.

From the picture, this looks very much like "top pincushion" trouble. In this chassis, there is a corrector tube, V11 on the Zenith diagram, a 6KT8. I'd try a new tube first. If this does not correct it, run the pincushion adjustment.

Put a crosshatch pattern on the screen, and adjust the "TOP PIN PHASE" control until the line straightens out. If this control has no effect, check the waveforms in the pin-corrector circuit. Look for the characteristic "bow-tie" waveform on the triode plate of the 6KT8. There will be no dc voltage on the cathode, but the red-green wire goes back to the vertical ouput transformer and should have a 90-volt p-p vertical spike on it. If

these waveforms are missing or distorted, check the pin-transformer and the capacitors and resistors. There are only a few parts in this circuit, so it shouldn't take long.

Noises In Guitar Amplifier Speakers

There is a funny noise in the speakers of this high-powered guitar amplifier. It sounds something like a rattlesnake or a high-pitched hiss. I suspected the voice coils, and tried to take off the aluminum dust-cover to check, but I couldn't find anything that would dissolve it. What do you think?—D. K., Lompoc, Calif.

We used to have this kind of noise in small speakers, when the last couple of turns on the voice-coils came loose. It *is* possible that you've got the same trouble. However, I rather doubt it. Voice coils in the tremendously high powered speakers used on modern guitar amplifiers very likely have a heavy aluminum ribbon voice coil which wouldn't be apt to make this kind of "whish" noise. Incidentally, you're not about to dissolve that cement on these speakers. It's probably epoxy or something equally durable!

Take the speakers out of the enclosures to eliminate the chance of loose pieces in there. Set them on the bench and feed an audio signal generator into the input. Now, start at a very low frequency and vary the frequency upward until you hear the noise. A single tone signal will often show up this type of noise if it is really a loose part, etc. If you hear the same noise now, it is definitely in the speakers.

Due to the construction of these heavy-duty speakers, you'll probably have to send them back to the factory for repair. They're the only ones who can get them apart and put them back together properly!

Blue Cellophane Picture

When this RCA CTC38 is first turned on, the picture is normal, but has a bluish cast as if you were looking at it through blue cellophane. If you fiddle with the fine tuning, you *can get the color to flash in and out. After about 30 minutes it starts to work and keeps on. What is causing this?—F.B., Livingston, Mont.*

I've heard of slow-starting oscillators, but this is ridiculous! From the symptoms, your 3.58-MHz oscillator is not working. This will generally make the picture have a bluish cast, although there is really no "color" present.

Check the 6GH8 color oscillator tube and all dc voltages around that stage. Don't overlook the *filament* connections either. In some cases, poor grounding of the heater circuit has left this tube with a very low filament voltage, which would make the oscillator slow-starting. As a last resort, try a new crystal.

Intermittent Flashing, Motorola TS-915

At odd intervals, the screen of this Motorola TS-915 flashes brightly, and I lose the picture. Heavy retrace lines at the same time. Can't pin it down.—R. G., New Iberia, La.

Check the *control-grid* connections on the picture tube. In this chassis, they are all tied together and fed voltage through a voltage divider network to B+. (Color and video signals are all fed to the CRT cathodes in this circuit.)

These resistors are mounted on a terminal strip on the upper back part of the chassis. You may have a broken wire here, or an intermittent solder joint, etc., due to pulling the chassis in and out. If the grids open, this will let the CRT flash to a high brightness.

Calibration Voltage In Eico 460 Scope

I'd like to install a voltage regulator that will keep the calibration voltage constant in my Eico 460 scope. It varies when the ac line voltage varies. Do you have a circuit that will do this?—D. W., Fontana, Calif.

Actually, if your ac line voltage varies enough to upset the calibration voltage, it will vary the gain of your vertical amplifier stages in the same ratio, so you don't really have too much to worry about! They will both rise or fall by the same *percentage.*

If you do have severe ac line voltage variations in your area, the first thing to do is chew out the power company. If this fails, a better way to deal with the problem would be to use a primary voltage regulator, plugging the whole thing into it. There are several of these available. **R-E**

DID YOU MISS . . .
30 useful projects built around the RCA CA3018 IC start this month on page 22. Don't miss them.

UPDATE DIGITAL CLOCK
(continued from page 55)

decade counter is a transistor-transistor-logic and will operate to 15 MHz. Resistor-transistor-logic decade counters were tried, but we found only a few of them would operate at 10 MHz.

The SN7490 decade counter has been designed so it is possible to effectively jump the first flip-flop and use the remaining flip-flop to count up to six and reset to 0. This makes it possible for the second "seconds" readout (V5) to display 1 to 5 (for 10 to 59 seconds) and the second "minutes" readout (V4) to display 1 to 5 (for 10 to 59 minutes) and reset to zero when it tries to go to a six. The remaining SN7490's are operated as decade counters. All of this is explained in the September, 1969, issue of RADIO-ELECTRONICS. In the frequency-dividing chain the input to the first decade counter is 10,000,000 Hz and the output is 1,000,000. The second output is 100,000, the third 10,000, 1,000, 100, 10 and finally 1 pulse each second. These frequencies are so accurate that they can be used for testing, markers, or "poor man's" secondary standards.

Since the clock will never be unplugged it is important that all safety regulations are observed. An ac fuse type plug (ELMENCO with 1-amp 3AG fuses) should be used, and if possible the unit should be mounted in a well-ventilated metal box. One suggestion is that the power supply be built in the line cord so the clock unit itself can be made smaller and more variable in design. A size 5¼ X 3 X 2⅛" box is about the correct size. If the power supply is on the same chassis as the clock board, it is possible to use a 7 X 10" printed circuit board and expose the clock section on one side or on the front. This will leave enough unetched copper for the power supply.

The printed circuit board is made so that no other instructions are necessary to complete this part of the clock. A cut-out decal is shown that can be put on top of the board with rubber cement. This gives the location of the IC transistors, etc., and also the arrows point to the direction of the marker on the IC. The #1 pin goes toward the direction of the arrow. Oftentimes, an IC can be installed in a socket incorrectly without damage. If it is taken out quickly no damage will result, but the slightest leakage or discharge from the 170-volt line will completely destroy the IC at once. So be especially careful with the 170-volt line.

Generally, a 10 to 15,000-ohm, ½-watt dropping resistor is placed in each 170-V lead to the readout tube. A 27,000-ohm resistor should be used to lengthen the life of the tube. We found that the tube has enough brightness and would strike each time. The purpose of this resistor is that when no current flows there is no voltage drop, and the full 170 volts is on the tube. When the switch is closed in the readout driver, IC current flows and the current drops to a safe operating value. After the tube has fired it no longer needs this high voltage, but only enough to keep it lighted.

Sockets are recommended but not necessary. They pay for themselves in case of trouble. If sockets are not used for the 5750 tubes the wires are long enough to reach the terminals. Alpha teflon sleeving #TFT 200 for size 22 wire should be slipped over the wires. The circuit boards are drilled with a #60 drill for mounting the IC and transistor sockets and readouts. A size #50 drill is used for the crystal oscillator. Pliers or heat absorbers should be used when soldering in the 1N191. Also, do not mount the resistors too close to the chassis as they could cover up the printing.

All jumpers and parts are mounted on the underside of the board. Also, remember that the copper on the printed board can be pulled off easily. Solid intercom cable makes good hook-up wire; and old telephone cable with size 24 wire is ideal. It has many colors and is easy to use. As it is necessary to use some jumpers, letters are shown for this. An **A** goes to an **A**, **B** to **B**, etc. All grounds go to **G** and all 5+ points go to the 5-volt line. Numbers were used for the readouts: IC2 goes to V2, IC3 to V3, etc. Since V2 is wired so it will reset to 1 instead of 0, it does not follow the same pattern as the others. Of course, V1 is used with the 2N3440 transistors.

Transformers were used for all voltages so the unit would not be of the ac-dc variety.

The complete unit takes 500 mA at 5 volts for the decade counter clock unit, 9.5 volts at 3 mA for the crystal oscillator and 20 mA at 170 volts. A transformer that had these voltages could not be found, so a Stancor PS-8416 was used. It has two windings, 250 volts CT and 6.3 volts at 1 amp. For the 9.5 volts the transformer can be easily disassembled and 60 turns of No. 32 enameled wire added over the other windings. The transformer can be taken apart quite easily and reassembled without too much effort.

It took 30 minutes to complete one on a trial basis. The windings are held tight by a small wooden wedge that must be removed before the laminations can be taken apart. They should be taken apart one at a time without bending any. The voltage for the oscillator is not critical. Any voltage from 3 to 9.5 worked well. It is important that the voltage remain constant so the frequency does not vary. A Zener is used for the purpose. Anyone who does not want to add the turns can use another transformer of the smallest type available, (12 volts), and a 1200-ohm resistor before the Zener instead of the 300-ohm. The 5-volt power supply supplies the 10-MHz countdown unit as well as the clock unit. They have been separated so it would be possible to make a printed circuit board of the counter or clock section separately. The clock unit can be used as a slave so that it does not need the countdown section. **R-E**

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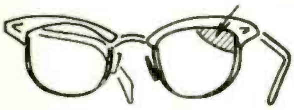
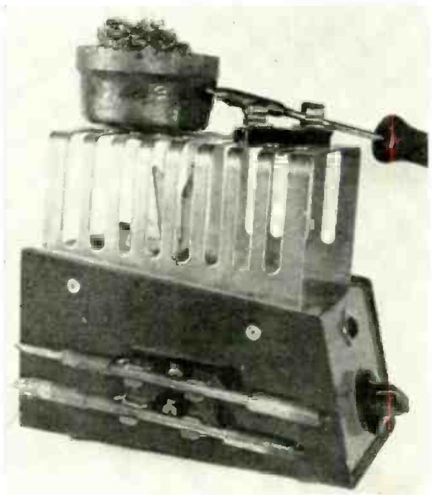
If you are one of the thousands who wear glasses and work in the field of electronics, you probably have been faced with the problem of trying to read some schematics and when repairing or replacing some of today's miniaturized components. At such times you have probably wished for another pair of hands to hold a magnifying glass. Well, you don't have to have that frustrated feeling anymore.



Just go to your optometrist and have him cement a magnifying chip (7 to 12 power) in the corner of your lens—left or right depending upon personal choice. The chip will end up about 15 mm × 6 mm, and when cemented to the back side of your lens, you will find that it will not interfere with normal vision. When you have to take a close look at a printed circuit board, you have both hands free to hold components and inspect for damage, etc. The cost will generally be less than \$10.—*Edward F. Xiques*

DON'T LOSE THOSE SOLDERING TIPS

Various size soldering tips won't get lost if you clip them into a multi-fuse block attached to your bench soldering iron control box. A two-inch

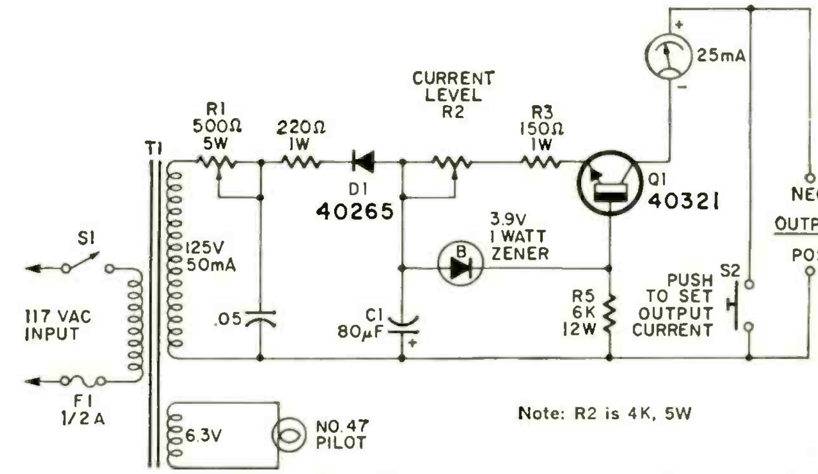


pipe cap, filled with steel wool, attached to either your bench or soldering iron case allows a one handed "dunking" operation to clean the soldering iron tip.—*John F. Agee, K5ODN* **R-E**

NOTEWORTHY CIRCUITS

LOW-LEVEL CURRENT-REGULATED POWER SUPPLY

The current-regulated power supply shown in the photo and schematic is simple to build and occupies little space on the test bench. Nevertheless, it comes in very handy indeed for those frequent little jobs such as testing neon lamps and Zener diodes. In the interims, it is kept busy as a rejuvenator and trickle charger for flashlight batteries!



Note: R2 is 4K, 5W

When the instrument is initially put into service, a voltmeter is connected temporarily across capacitor C1, and potentiometer R1 is adjusted for a meter reading of 125 to 130 volts. The output current will then be continuously variable from 1 mA (with the resistance of R2 entirely in the circuit) to 25 mA (when the resistance of R2 is zero). In any individual instrument, it may be necessary to alter the value of R3 slightly, one way or the other, to obtain exactly 25 mA output when R3 is set in its fully clockwise position.—*Frank H. Tooker*

R-E

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  All antenna needs are not alike. Each installation has its own problems. See how to set up your antenna to deliver maximum performance.

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Kwik-Fix Troubleshooting Charts
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Anti-Sleep Alarm To Build For Your Car
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PORTABLE VTR'S
(*continued from page 62*)

drives a voltage regulator that controls the vidicon's target voltage. In this way a constant video level is assured over a wide range of lighting conditions.

Output video is also routed to a signal processor where the signal is clamped and applied to an output emitter follower. Vertical and horizontal sync are added to the signal at the input to the emitter follower. One output of the emitter follower drives a voltage amplifier through the contrast control to supply about 40 volts p–p for the viewfinder CRT. The remaining output lead of the emitter follower is routed through the connecting cable to the vtr.

The camera uses two deflection oscillators (vertical and horizontal) that are driven by V&H drive sent up from the vtr. Each deflection oscillator drives a pair of deflection-output systems. One deflection system drives the yoke on the vidicon; the other drives the yoke on the 1-inch CRT. Retrace pulses produced in the oscillators and flyback transformers are used as byproducts to generate H and V sync. A pulse-stretching blanking amplifier also uses these pulses to generate blanking signals.

The photo shows the guts of the DVC-2400. Note that the viewfinder CRT uses a small doughnut-shaped PM magnet to adjust focus.

Most vtr manufacturers are now taking the wraps off a new family of ½-inch vtr's built to the EIAJ standards (EIAJ = EIA of Japan). Included in these families are brand-new portables. The photos show some of the newest. The Sony AV-3400 has a sophisticated two-motor servo system that permits the servo to lock up to externally supplied video as well as the video supplied by the captive camera. It also can rewind and play back the tape with the picture appearing in the viewfinder. An optional modulator permits the operator to see the video on any TV set. **R-E**

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ADVERTISING INDEX

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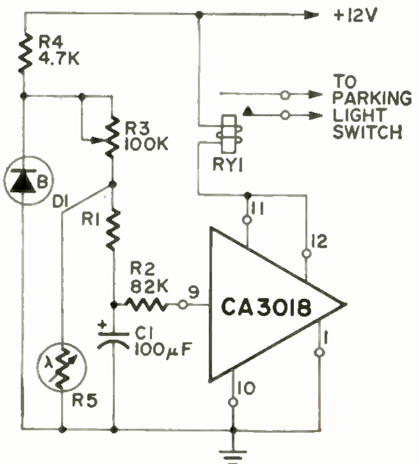
30 I.C. Projects
(continued from page 28)

If the metal probes are an open circuit, pin 9 is effectively shorted to ground via R1, so Q3–Q4 and the relay are off. If the probes are shorted, either directly or via a resistance of less than 500,000 ohms, enough bias is applied to pin 9 from the positive supply line to drive Q3 and Q4 to saturation, and the relay is driven on. Since water normally has a moderately low electrical resistance, the relay can be driven on simply by placing the two metal detector probes in water.

This simple circuit has a number of practical applications in the home. Using simple metal rod or sheet probes, for example, it can be used to operate an alarm when bath water reaches a predetermined level, or when flooding occurs in basements, etc.

Using closely spaced wire probes, it can be used to sound an alarm or turn off electrical supplies when steam impinges on both probes simultaneously (to automatically turn off an electric kettle as soon as the water reaches the boiling point).



NOTE: RY1 = ANY 12-V RELAY WITH A COIL RESISTANCE GREATER THAN 240Ω.

Another useful type of relay-driving gadget is shown in Fig. 15 above. This is an automatic parking-light operator for your car. The design is basically similar to that of the water-operated switch, with Q3 and Q4 connected as a Super-Alpha pair wired in the common-emitter mode, with the relay as a collector load and with input applied to pin 9. The input is obtained from a light-level sensing network.

Resistor R4 and Zener diode D1 act as a simple voltage stabilizer, and apply a fixed potential of 6 volts to the top of R3, irrespective of actual battery voltage. Resistor R5 is a cadmium sulphide photocell that acts as a low resistance under bright conditions and as a high resistance under dark conditions. Resistors R3 and R5 act together as a simple voltage-divider network, so the voltage at the R3–R5 junction varies in proportion to the light level on the face of R5. This voltage is smoothed by R1 and C1 and is passed on, via R2, to pin 9 of the IC.

(continued next month)

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