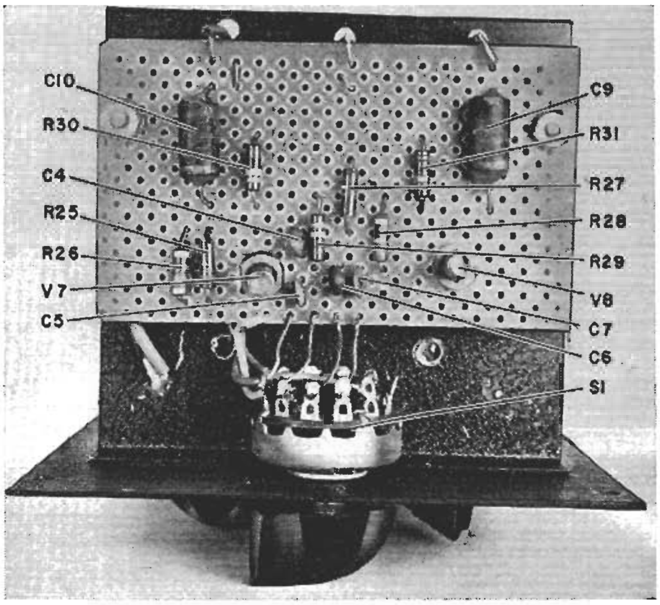
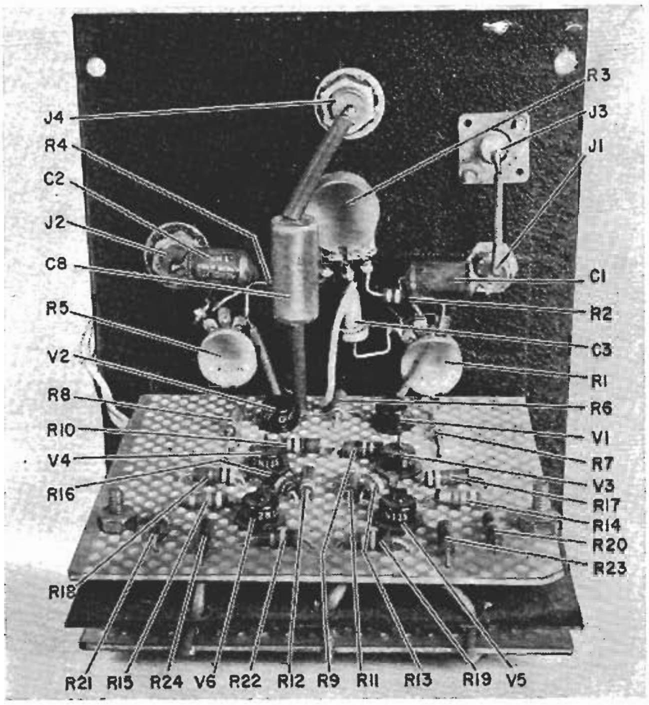




Closeup (above) of multivibrator board. Top board (right) holds major portion of circuitry.

By **DAVE STONE**

TRANS-SWITCH—

electronic scope switch

8-transistor unit is a cinch to build

The Trans-Switch is an all-transistor scope attachment that lets you display two different waveforms simultaneously on your scope screen. You can, for instance, compare an audio amplifier's input and output signals so any distortion or phase shift can readily be noted. Or you can compare input and output waveforms of a square-wave converter, pulse amplifier, delay circuit or the like. Generally, any two signals in the audio range that are related to each other can be fed into this switching unit for comparison or matching.

Eight transistors are used in the Trans-Switch (see schematic). All are inexpensive. The other components are standard miniature types, and overall cost of construction is nominal. Layout and construction are not critical—you can build this unit in almost any manner you desire. All components shown in the photos are miniature types but can be replaced with standard-size equivalents if compactness is not important.

How it works

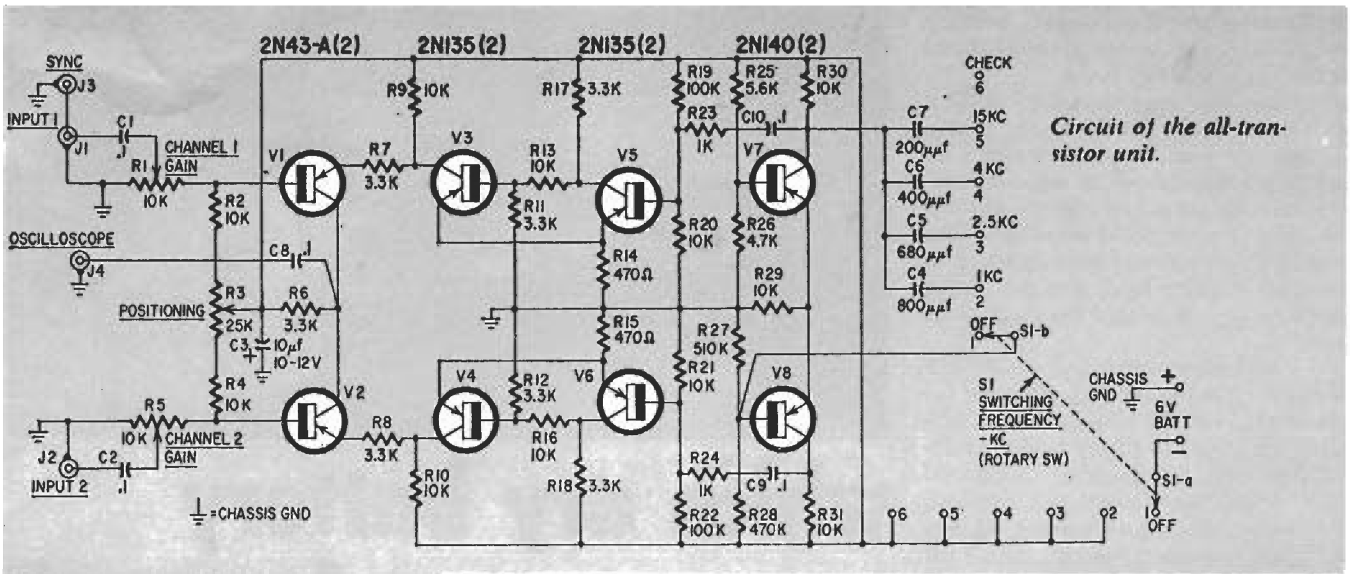
The heart of the circuit is the switching amplifiers V1 and V2. First, V1 conducts. Its input signal is amplified and fed to the scope, while V2 is cut off. At the end of the period determined by SWITCHING FREQUENCY control S1, V1 is driven into cutoff and V2 conducts to pass its input signal to the scope. This switching action is too rapid for the eye to follow and results in two simultaneous traces on the scope screen.

The switching frequency is generated by V7 and V8 arranged in a multivibrator circuit. S1 selects different timing capacitors to change the R-C time constant and produces switching frequencies of approximately 1, 2.5, 4 and 15 kc. The output pulse at V7's collector is 180° out of phase with the output pulse obtained from V8's collector. At any one instant V5's base is driven with a negative pulse from V7, and V6 receives a positive pulse from V8. During the next instant the pulse polarities reverse to place a positive signal at V5's base, and a negative pulse at the base of V6.

Transistor pairs V3 and V5 and V4 and V6 are squaring circuits that convert the multivibrator's pulses to fast-rising square waves to drive the emitters of V1 and V2. When a negative pulse is fed to V5's base, it produces a positive square wave at V3's output which drives V1 into conduction. At the same time, the positive pulse at V6's base produces a negative square wave at V4's output which drives V2 into cutoff. Then the switching action reverses itself. Any signals fed into the base circuits of V1 and V2 are sent on to the scope as the transistors alternately conduct and produce two distinct signal waveforms on the scope screen.

The CHECK position on S1 is for checking the condition of the battery. It allows power to be applied to the unit, but disables the multivibrator by removing the timing capacitor, and allows only a single trace to appear on the scope screen. If the battery is in good condition, any signals at the input jacks will be amplified and appear on the single trace. Power requirements are only 3 to 4 ma at 6 volts, so the battery will last a long time.

POSITIONING potentiometer R3 moves the two traces closer or farther apart, or it can be used to put one trace on top of the other. The input signal level to each amplifier stage is controlled by CHANNEL GAIN potentiometers R1 and R5.



Circuit of the all-transistor unit.

R1, R5—miniature pots, 10,000 ohms
R2, R4, R9, R10, R13, R16, R20, R21, R29, R30, R31—10,000 ohms
R3—miniature pot, 25,000 ohms
R6, R7, R8, R11, R12, R17, R18—3,300 ohms
R14, R15—470 ohms
R19, R22—100,000 ohms
R23, R24—1,000 ohms
R25—5,600 ohms
R26—4,700 ohms
R27—510,000 ohms, 5%
R28—470,000 ohms
All resistors ½-watt, 10% unless noted
C1, C2, C8, C9, C10—0.1 µf, 200 volts paper
C3—10 µf, 10 or 12 volts, miniature electrolytic or tantalum
C4—800 µµf, mica or ceramic
C5—680 µµf, mica or ceramic
C6—400 µµf, mica or ceramic
C7—200 µµf, mica or ceramic
BATT—6 volts (author used 7.5-volt bias battery tapped at —6 volts)
J1, J2, J3, J4—coaxial or audio jacks
S1—6-position 2-pole rotary
V1, V2—2N43-A
V3, V4, V5, V6—2N135
V1, V8—2N140
Chassis and case to suit (see text for size of unit author used)
Miscellaneous hardware

Construction

A 4 x 5 x 6-inch steel cabinet with an attached shelf was on hand, and all the circuitry, with the exception of the jacks and potentiometers, was mounted on two perforated boards and attached above and below the shelf, The pots, input and output jacks and switch S1 are mounted on the front panel. Although layout and lead dress are not critical, the use of small low-voltage components and close placement of transistors will result in short lead lengths.

The upper board contains the circuitry for transistors V1 through V6. V1 and V2 are mounted at the front of the board close to the input controls. V5 and V6 are mounted at the back of the board. The flexible leads of these transistors are wired directly into the circuit.

The lower perforated board contains the multivibrator transistors V7 and V8, whose short rigid pins require sockets. Timing capacitors C4 through C7 are small ceramic or mica units mounted close to S1 to provide direct wiring. Leads from coupling capacitors C9 and C10 go through the shelf to connect to the circuitry on the upper board.

A C-bias battery was selected for convenient mounting feature of its flat shape, and is fastened with brackets to the top of the enclosure.

The constructor can vary the layout by mounting all the components on a single board, or larger components can be substituted. Coaxial type jacks were used for their small size, but any good quality jack can be used. Be sure to grip the flexible leads of the transistors with long-nose pliers to dissipate excess heat while soldering.

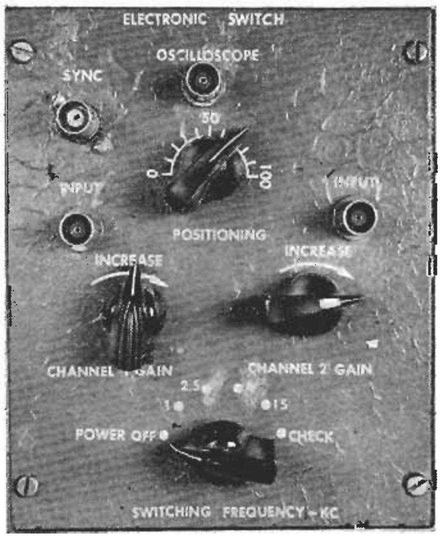
Checkout and use

After the unit is assembled, insert a milliameter in series with the negative battery lead. Turn S1 to the 1 KC position and note whether the current drain is in the normal range of 3 to 4 ma. If it is appreciably higher, switch to POWER OFF immediately and recheck the wiring, and transistors if necessary, to determine the defect.

If the drain is normal, leave S1 in the 1 KC position and connect a lead from the OSCILLOSCOPE jack to the scope's dc input jack. The dc input connection is recommended since most inexpensive scopes have better square-wave response without the coupling capacitor used in the ac position. Set the scope's sync selector to internal and note a square wave appearing on the screen. If it is not perfectly symmetrical, or has some spikes riding on it, don't be too concerned; they do not affect the operation of the switching unit.

Connect a lead from the switcher's SYNC jack to the scope's external sync jack and rotate its sync-selector switch to the external position. Two distinct traces will appear on the screen, and rotating R3 will move them closer or farther apart. Note the appearance of the two traces at all settings of S1, except in the CHECK position. Return S1 to the 1 KC position, connect the audio generator, set at 10 kc, to the CHANNEL 1 input jack. Rotate the gain control for this channel to its full open position and adjust the generator output for a sine wave on one of the two traces. Run a parallel lead from the audio generator to the CHANNEL 2 input jack, and adjust its gain control for a sine wave on the other trace. Then adjust the POSITIONING control to superimpose both waveforms to obtain a single trace. If the waveforms mesh perfectly, it indicates that both amplifier stages are identical as far as phase shift is concerned.

Become thoroughly familiar with the action of all controls and experiment with the sweep frequency ranges on the scope, as well as the amplitude controls of both Trans-Switch and scope. The selection of the switcher's best switching frequency setting depends upon the frequency of the signal fed into it. As a rule of thumb, use the 1-kc setting for input signals between 10 and 25 kc, the 2.5-kc position for signals between 1.0 and 10 kc, the 4-kc setting for signals in the 100 to 1,000-cycle range, and the 15-kc setting for frequencies below 100 cycles. In any case, adjust S1 for the smoothest waveform traces possible. At all positions, the switching action may show up as a light



Front-panel view of the instrument.

background haze if the scope's intensity control is turned up, but it hardly shows at the usual intensity level.

Once you are thoroughly familiar with the controls, put the unit to practical use. An amplifier can be tested by injecting a signal from an audio generator into the amplifier's input and the CHANNEL 1 input at the same time. The amplifier's output can be terminated in its usual resistive load, and the output signal picked off to feed the CHANNEL 2 input.

Connections between Trans-Switch and scope are the same as those for the checkout; J4 to the scope's vertical amplifier dc input, J3 to the scope's external sync jack, the scope set to external sync. Adjust the channel gain controls, positioning, scope gain control, S1 and the scope's sweep frequency switch for equal-amplitude signals on both traces. The signals can now be compared for any possible distortion, or superimposed for phase-shift comparison. Adjustments to the amplifier can now be made and the results, relative to the input signal, can be readily observed on the scope.

In all applications, bear in mind the Trans-Switch input impedance is dependent upon the setting of the gain controls, so a high-impedance connection to the input jack may have to be isolated with a pad or small capacitor to avoid loading the equipment being checked. As a general tool and useful oscilloscope attachment, the Trans-Switch is hard to beat for all audio work. END

After the Computer, What?

(*Continued from page 23*)

still take a year to produce an intellectron.

In addition, after completion, the intellectron must still *continue to learn* new facts from time to time—just as humans must—if it is not to fall behind in its general knowledge.

Yet with all these "human" accomplishments, the intellectron will still be a machine.

Then what good are these intellectual machines? They will be able to do thousands of tasks and replace humans who will rarely compete with them. You could give verbal orders to them and count on getting back correct evaluated answers from their encyclopedic memories, either *verbally* or typed out neatly in a variety of languages.

They will become invaluable in commerce, business, science, literature, and in all the arts. They will be robots, but *intellectual* robots.* —*H.G.*

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*See also "Billions of Electronic Facts," December 1959 RADIO-ELECTRONICS; "Brain An Electric Computer," March 1960 RADIO-ELECTRONICS, and "Are Thinking Computers Possible?", August 1962 RADIO-ELECTRONICS.

which dry battery for you?

There is a best dry battery for every job. This article will help you pick it out.

by GORDON E. KAYE*

DRY BATTERIES ARE MADE IN THREE COMMON types, commonly called zinc-carbon, alkaline and mercury. The zinc-carbon battery is further divided into four varieties. These were described in the article "What Is A Dry Battery?" in the May, 1963, issue. Each of these types has its own best applications, due to its composition or the proportions of the elements used in its mix. The table illustrates some typical consumer applications and the reasons for choosing correct battery types for them. There are hundreds of other industrial, military and commercial devices using dry batteries.

A rather special application is that of voltage standard. The industrial-grade mercury battery may be used as a voltage-reference source. (Some varieties of mercury cells made with a manganese dioxide blend are not suitable as a voltage reference. The MnO_2 causes a reading of 1.4 volts. This can be spotted easily.) At intermittent drains up to 1 ma, it is within 1% of its original 1.357 volts for a period of 2 to 10 years. Aged cells, after 3 years, can have a long-term stability of 0.1%.

Direct measurements may be made on these cells with ordinary voltmeters. Voltage potentiometers are not needed, except where more precise readings are required and calibration against a primary standard is called for. You can attain short-term accuracies in the order of one part in a million, especially if the temperature is a stable 120°F, and the cell has been aged. The average open-circuit voltage of these cells doesn't seem to drift over the years, as shown in Fig. 1.

Selecting a battery type

The simplest economic viewpoint

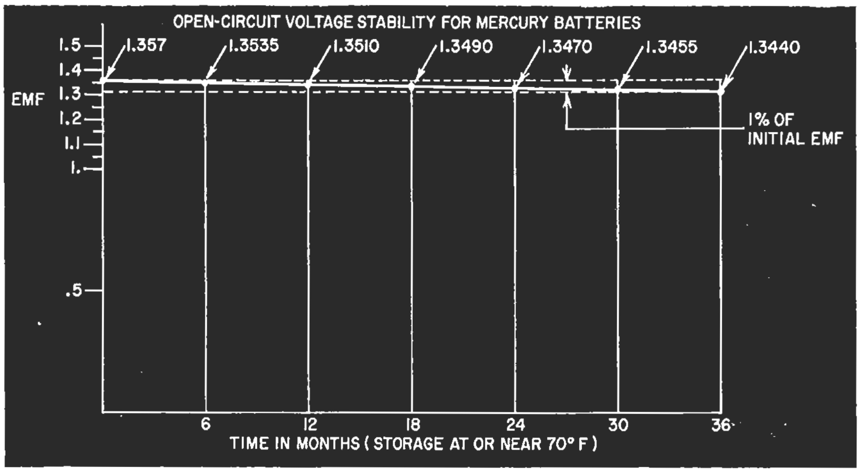

Fig. 1—Chart shows excellent shelf-life of mercury cells and batteries.

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*Application engineer, Mallory Battery Co.