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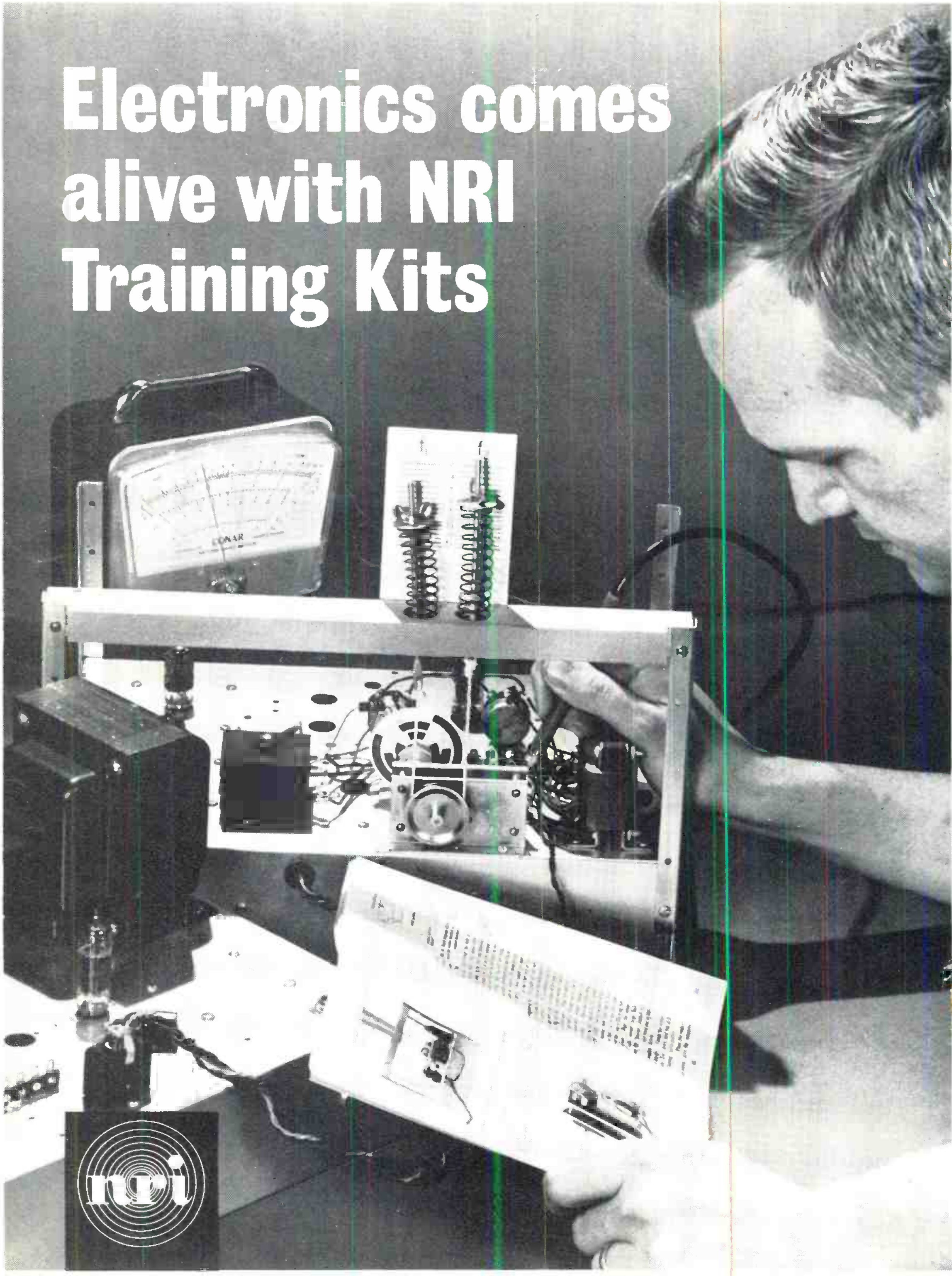
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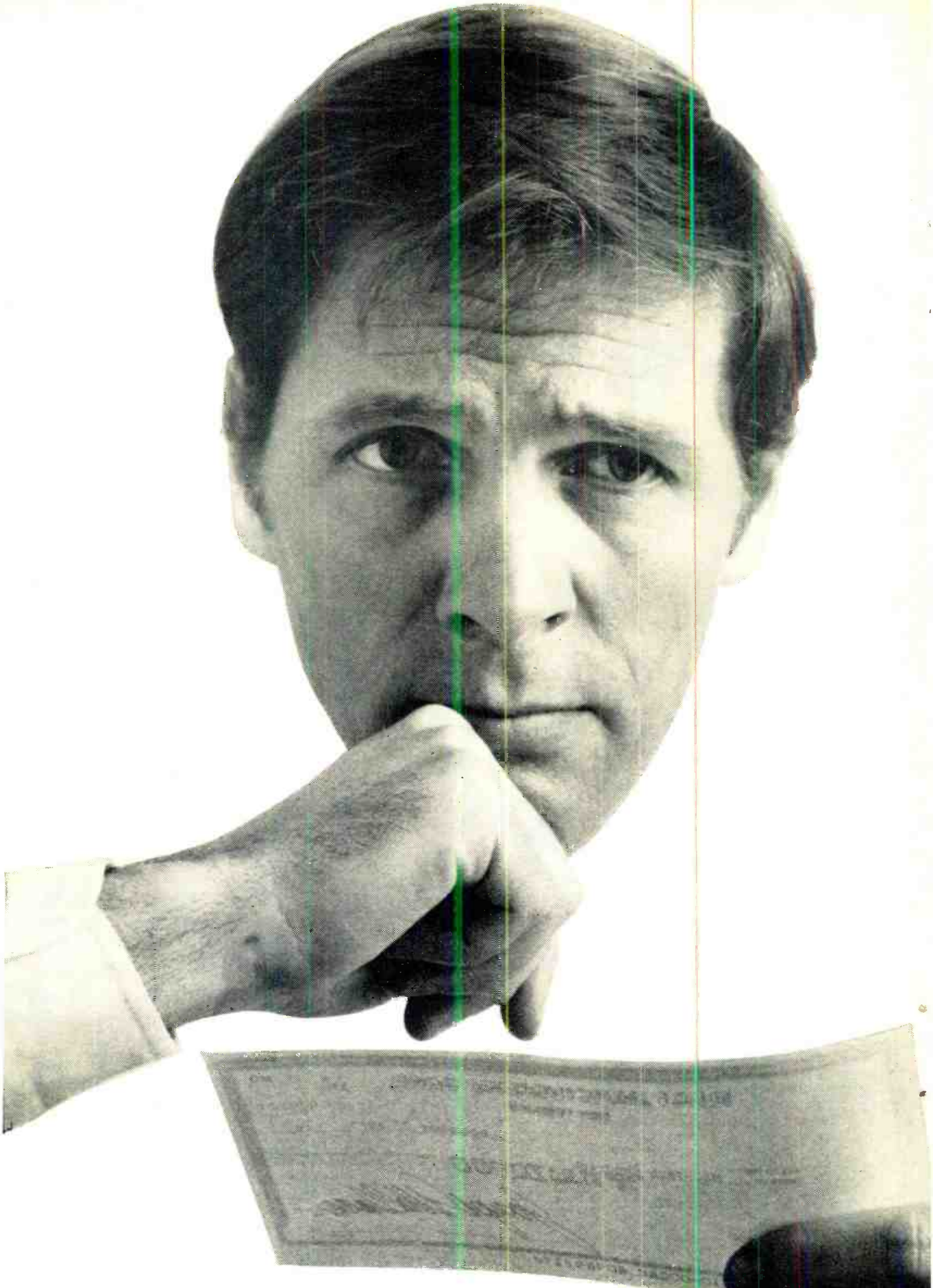

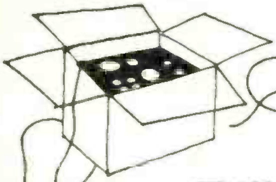

NEW PRODUCTS

Additional information on products described in this section is available from the manufacturers. Each new product is identified by a corresponding number on the Reader Service Page. To obtain additional information on any of them, circle the number on the Reader Service Page, fill in your name and address, and mail it in accordance with the instructions.

MCINTOSH LOUDSPEAKER SYSTEMS—An established producer of electronic high-fidelity components, *McIntosh* has added loudspeaker systems to its line. The unit pictured here contains four speakers: one 12" handles frequencies up to 250 hertz; then an 8" takes over and continues to 1500 Hz; a 1½" dome mid-range speaker carries the radiation pattern to 7000 Hz; and a compound coaxial continues to 14,000 Hz on the outer diaphragm and to above 20,000 Hz on the ½" inner diaphragm. Other larger systems contain up to eleven speakers. Two systems are required, of course, for stereo and a complete installation must use an equalizer (also by McIntosh) for left and right bass and mid- and high-frequency differences.

Circle No. 79 on Reader Service Page 15 or 95

JOHNSON CB TRANSCEIVER TESTER—Worried about your CB transceiver's operation? The E. F. Johnson Co. has a new checker that will test transceiver performance in a number of ways and also monitor the on-the-air signal continuously. It reads true r-f power output, modulation, and SWR; and can be installed to read received S units with transceivers that don't have S-meters. A built-in dummy load can be used to make tests off-the-air and, without changing cables, switch to the antenna to transmit. It's all solid-state, portable and battery operated.

Circle No. 80 on Reader Service Page 15 or 95

SOUNDCRAFTSMEN STEREO EQUALIZER—Accurate tuning of the frequency response of a stereo system and listening room to a flat ±2 dB is possible with the *Soundcraftsmen* Model 20-12 Audio Frequency Equalizer. Toroidal and ferrite-core inductor passive circuits and active transistor circuits allow a 24-dB range of equalization for each of 10 octave bands per channel. An additional 18-dB range of full-spectrum boost or cut compensates for acute response nonlinearities. Frequency response is ±½ dB from 20 to 20,480 Hz at zero setting.

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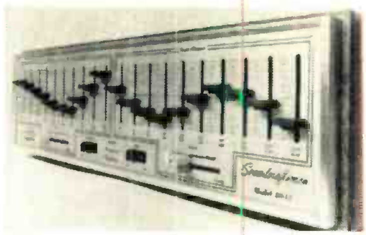

COUSETTE AUTO TUNE-UP CASSETTE—If the current price of a tune-up for your car intimidates you and if you have a portable cassette recorder, *Coursette System, Inc.*, a producer of programmed audio-visual instructions, now has detailed instructions for tuning up your car on cassette tapes. "Tune-Up-Tapes" are currently available for Volkswagen, Maverick, Opel, Volvo, Porsche, and BMW cars—others are being developed. The tape kit includes an engine diagram, tool and parts list, service record sticker, and window decal.

Circle No. 82 on Reader Service Page 15 or 95

DYNASCAN VHF MONITOR—Listening to the police, fire, business, and government channels is made easier by the Cobra PF-1 monitor, introduced by *Dynascan Corp.* It has separate front ends and separate tuning knobs for the low (30-50 MHz) and high (152-174 MHz) VHF bands, and tunes manually across the bands. Provision is made for crystal-controlled operation at a specific frequency in each band. The PF-1 operates on ac or dc—117 volts ac for base station use; 12 volts dc for mobile use (negative ground). In addition: a jack for headphone or 8-ohm speaker, auto antenna jack, squelch control.

Circle No. 83 on Reader Service Page 15 or 95

TOMPKINS RECEIVER MONITOR—For those who must keep in touch with a base station, but can't always be near the receiver, the *Tompkins Radio Products* Mobilink is a welcome accessory. Mobilink is a low-power AM transmitter and companion pocket receiver which can be used with any type of receiver and has a range of ¼ mile. The transmitter, which uses a 9-volt battery, is connected to the speaker of the receiver to be monitored. Transmitter frequency is 27.263 MHz or any CB channel on request. It is crystal controlled and has an input impedance of 3 to 8 ohms. The pocket receiver has an 18″ collapsible antenna.

Circle No. 84 on Reader Service Page 15 or 95

GARAGE DOOR RADIO CONTROL—A new "impossible to jam" radio control circuit is being introduced by Teaberry Electronics. Secret of the new control method is a system of generating carrier pulses at one of 19 pulse repetition frequency (PRF) rates. The PRF codes range from 11 to 75 Hz. The control transmitter operates on one of 22 frequencies between 71.9 and 72.95 MHz. The control receiver will be a crystal-controlled super-regenerative with a "Tee" filter. Switching is done with a triac. Complete garage door operator facilities will be made available.

Circle No. 85 on Reader Service Page 15 or 95

HOLLYWOOD AF GENERATOR—Sine and square waves from 10 Hz to 100 kHz in four fundamental bands are obtainable from *Hollywood Instruments, Inc.*'s Model 7000 Mini-AF Generator. With a FET in the oscillator circuit and a thermistor and heavy negative feedback, constant output signals of low distortion are provided over entire frequency range. Accuracy is ±4% × 1 Hz; frequency response, ±2 dB at 1 kHz, weight 1.7 lb.

Circle No. 86 on Reader Service Page 15 or 95

HARMAN-KARDON PREAMPLIFIER/AUDIO EQUALIZER—Versatility in an audio preamplifier seems to have reached some sort of peak in *Harman-Kardon's* Citation Eleven. It combines the functions of a high-quality preamp with equalizer controls—five of them—instead of the usual base and treble knobs. (The equalizers affect both channels in the same way.) Frequency response is ±0.5 dB from 2 to 200,000 Hz and the square wave rise time at 20 kHz is 1.0 microsecond in all functions.

Circle No. 87 on Reader Service Page 15 or 95

Now it costs less to own the best oscilloscope you need.

The New RCA WO-505A Solid-State Oscilloscope

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*Inexpensive Quality
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RCA

The best you need is the new 5-inch RCA WO-505A, all solid-state oscilloscope. It makes yesterday's general-purpose 'scopes look old-fashioned.

At just $298.50† the WO-505A offers an unmatched list of features usually found only in more expensive, laboratory-type instruments. For example there's the all solid-state circuitry . . . an illuminated graph screen calibrated directly in volts, and a deep-lip bezel for exceptional clarity. The regulated power supply minimizes trace bounce and provides excellent stability. And the camera mounting studs offer still more evidence of the functional value built into the new WO-505A.

But you've got to see this new RCA 'scope in operation—see the sharp, clean trace it provides—to appreciate it.

Some statistics:

- High-frequency response, usable to 8 MHz.
- High Sensitivity (.05 V p-p range).
- DC vertical amplifier; DC/AC input.
- Return trace blanking . . . Trace polarity reversal switch . . . Phase control.
- High-frequency horizontal sweep; solid lock-in on 5 MHz.
- Preset TV "V" and "H" frequencies for instant lock-in.
- Built-in square-wave signal for calibrating P-P voltage measurements.
- Provision for connection to vertical deflection plates of CRT.

Some statistics! For complete details, contact your RCA Distributor.

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CIRCLE NO. 18 ON READER SERVICE PAGE

COVER STORY

BY DON LANCASTER

BUILD THE

PSYCH-TONE

MELODY SYNTHESIZER WITH 28 CONTROLS & 63-NOTE MEMORY

This is a new and unusual approach to music synthesis. The sounds it produces are modern—to say the very least—and the operation is extraordinarily simple. Technically, this is a "psuedo random sequence generator" operating as a tune computer with tempo, voicing selection, tone shaping, and pause gates.

BEETHOVEN couldn't synthesize music like a Moog, nor could he be programmed to turn out a melody of the listener's own choosing. The "Psych-Tone" doesn't do those things either, but it is a real composer of synthetic music. Set up on its internal digital computer are 1728 different 63-note sequences that can be selected and combined with any of 63 pause combinations to produce 108,864 different melodic lines. These melodies can be played at almost any tempo, pitch, or volume and they can be played forward or backward, right side up (normal scale) or upside down (inverted scale). Six different voices are provided and the user has full control of the attack, sustain, and decay of the output.

Because of the wide flexibility of the controls, the music can have the sound of a violin, a piano, or something like nothing you ever heard before. On occasion, the music may

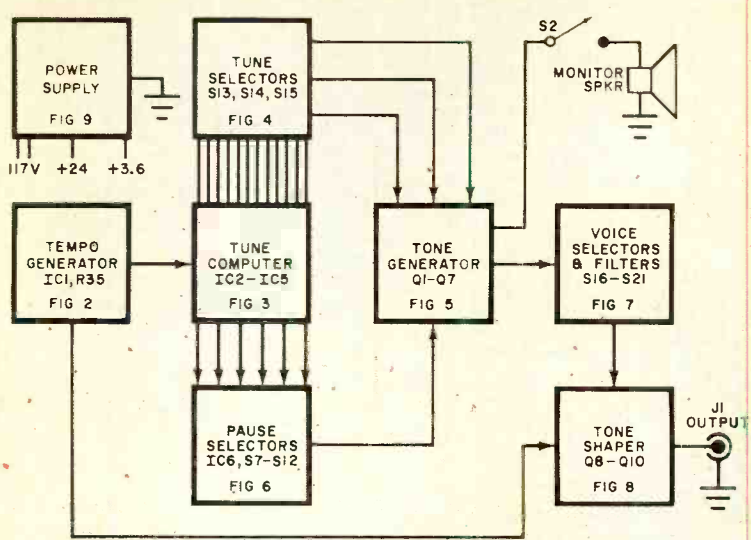

Fig. 1. The overall block diagram shows the signal flow for the system. Note that voicing filters and tone shaper are not linked to the monitor speaker.

PARTS LIST

C1—4000-μF, 6-volt electrolytic capacitor
C2—0.1-μF, 10-volt disc ceramic capacitor
C3—500-μF, 50-volt electrolytic capacitor
C4—100-μF, 25-volt electrolytic capacitor
C5,C10—0.047-μF, 50-volt Mylar capacitor
C6,C8—0.22-μF, 50-volt Mylar capacitor
C7,C15,C16,—47-μF, 6-volt electrolytic capacitor
C9,C12-C14—0.47-μF, 50-volt Mylar capacitor
C11—0.01-μF disc capacitor
D1-D3—1-ampere, 100-volt diode (1N4002 or similar)
D4—24-volt, 1-watt zener diode (1N4749 or similar)
D5-D7,D9—Silicon diode (1N914 or similar)
D8—3.3-volt zener diode (1N746 or similar)
IC1—Dual buffer (MC799P)
IC2-IC4—Dual flip-flop (MC791P)
IC5,IC6—Quad two-input gate (MC724P)
J1—Phono jack
Q1-Q3,Q7-Q9—Transistor (National 2N5129)
Q4—Transistor (National 2N5139)
Q5—Transistor (Motorola 2N4871, do not substitute)
Q6—Transistor (Motorola MPS6523, do not substitute)
Q10—Transistor (Motorola 2N4351, do not substitute)
R1—330-ohm, ½-watt resistor
R2-R4,R12,R31-R33,R36-R38—1000-ohm, ¼-watt resistor
R5-R7—22,000-ohm, ¼-watt resistor
R8-R10—100,000-ohm potentiometer
R11—11,000-ohm, ¼-watt resistor
R13,R18—1500-ohm, ¼-watt resistor
R14—5000-ohm potentiometer
R15—470-ohm, ¼-watt resistor
R16—20-ohm, ¼-watt resistor
R17,R20—100,000-ohm, ¼-watt resistor
R19,R28—4700-ohm, ¼-watt resistor
R21,R23—27,000-ohm, ¼-watt resistor
R22,R24,R25—1-megohm potentiometer
R26,R30—3300-ohm, ¼-watt resistor
R27—1000-ohm potentiometer
R29—2200-ohm, ¼-watt resistor
R30—3300-ohm, ¼-watt resistor
R34—8200-ohm, ¼-watt resistor
R35—10,000-ohm potentiometer
R39,R40—3.3-megohm, ¼-watt resistor
S1-S12—Dpdt rocker switch
S13-S15—Single-pole, 12-position, non-shorting rotary switch (Mallory 32112J)
S16-S21—Interlocked six-station dpdt push-button switch assembly (Southwest Technical SW-9678-stf or similar)
T1—Power transformer: secondaries: 24 volts at 100 mA, 6.3 volts CT at 400 mA
Misc.—Printed circuit terminals (47, optional), 3.2-ohm speaker, suitable chassis, subchassis, grommets (3), line cord with strain relief, bottom plate with mounting hardware, rubber feet (4), switch hardware, ground lugs (3), ⅝" knobs (9), ¾" knobs (3).
Note—The following are available from Southwest Technical Products, Box 16297, San Antonio, TX 78216: etched and drilled printed circuit board at $6.50, postpaid; complete kit with chassis, dialplate, and hardware at $47.65 plus postage and insurance for 7 lb.

sound familiar but it is more likely to have a science-fiction flavor with many wild tonal sequences.

The Psych-Tone can be used with its internal monitor speaker; but, preferably, it should be connected to an external power amplifier to take advantage of the various voices and the sustain, attack, and decay provisions which are not available when only the monitor speaker is used.

General Circuit Operation. The Psych-Tone consists of seven operational blocks and a power supply as shown in Fig. 1. The tempo generator determines the reference beat (or clock) for the tune computer, which cycles through 63 different states in step with the clock pulse. The three tune selector switches convert the initial 63-note sequence into any one of 1728 different combinations. The tune computer also drives a pause selector circuit that decides when pauses are to be produced instead of tones. The selected sequence of notes and pauses then goes to a tone generator where it is converted into audio tones.

In the voice selector (filters) the tones are shaped into one of six selected voices, in a manner similar to the operation of an electric organ. The tones are further shaped in a variable-gain circuit that provides for adjusting the duration (sustain), attack (how fast the tone reaches full volume), decay (how fast the tone dies away from full volume), and loudness.

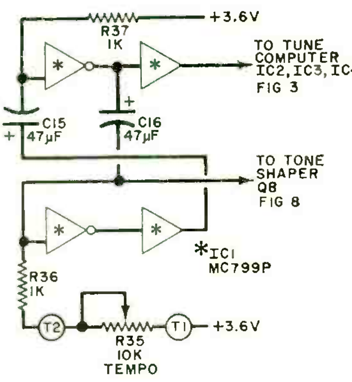

Fig. 2. The tempo generator is a simple oscillator made up from a single quad-gate IC.

Tempo Generator. This circuit, shown in Fig. 2, contains a single integrated circuit (*IC1*) operating as an astable multivibrator. Two square wave outputs are produced—one having a fast fall time and high drive capability for the tune computer, and the other for

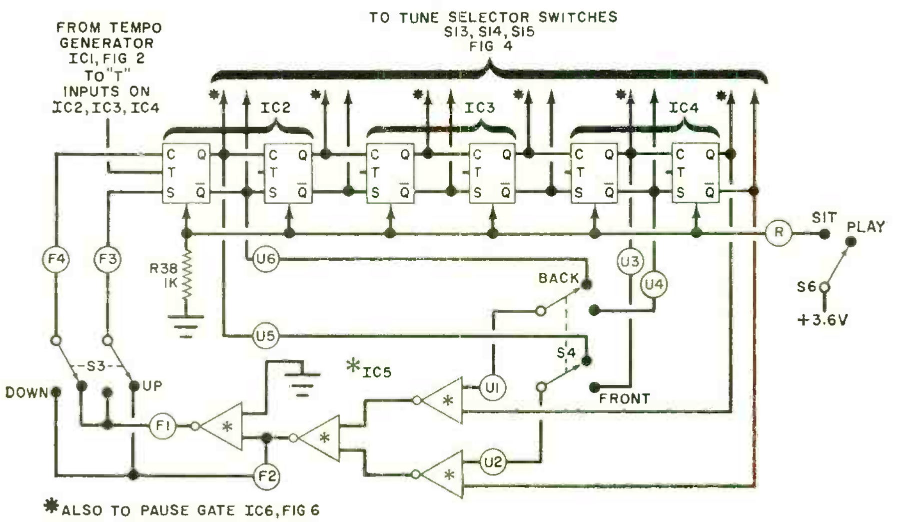

Fig. 3. The tune computer is a digital sequence generator that repeats every 63 counts and can be programmed for forward, backward, normal or inverted counting.

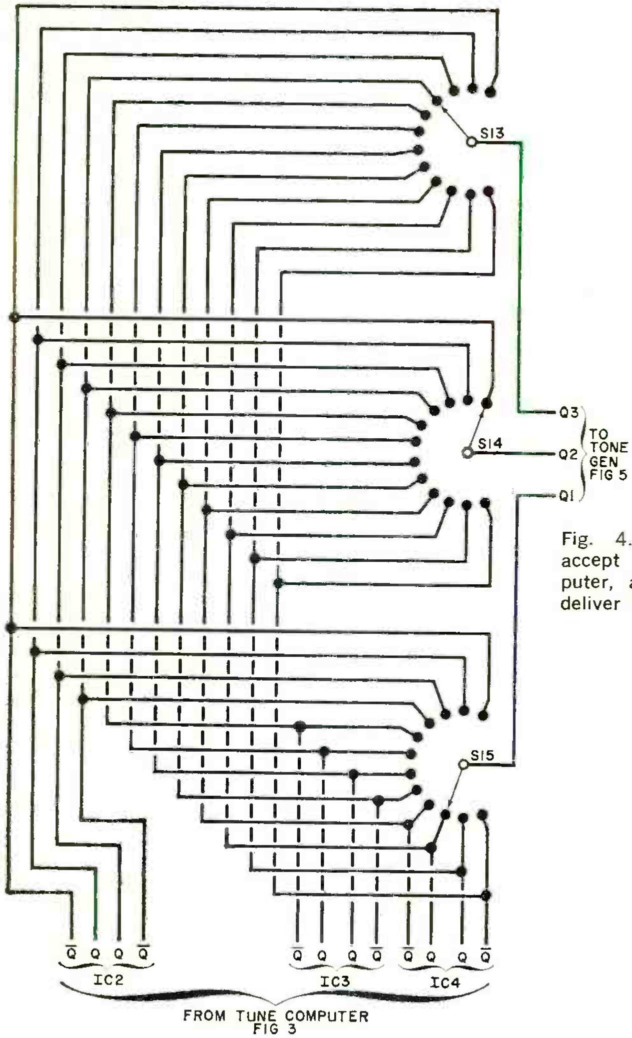

Fig. 4. Three tune-selector switches accept 12 outputs from the tune computer, and after the desired selection, deliver three signals to tone generator.

ALSO AVAILABLE

A recently introduced unit which is quite similar to the Psych-Tone is the Muse, made by Triadex, Inc., Newton Upper Falls, Mass. With 14 trillion note combinations, the Muse has four switches for volume, tempo, pitch, and fine pitch and eight slide switches. Four of the latter vary the interval and thus determine the notes, while the other four control the theme and variations of the melody. Triadex warns that it is possible to set up a composition that would take 30 years to play—which may be a little too long if you're only interested in the finale. The Muse is listed at $300.

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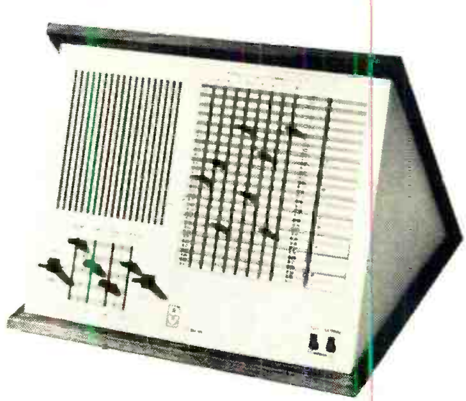


the tone shaper sustain circuit. The tempo (beat) is adjusted over a 5:1 range by potentiometer *R35*. If desired, the values of *C15* and *C16* can be increased or decreased to slow down or speed up the tempo, respectively.

Tune Computer. As shown in Fig. 3, the computer is a "pseudo random sequence generator." Like a random noise source, the computer sequences appear to be totally unrelated. However, this circuit can be programmed to return to exactly the same random sequence at any time. The logic consists of a six-stage shift register (*IC2*, *IC3*, and *IC4*) and an EXCLUSIVE OR gate (*IC5*). The shift register is toggled by the tempo generator described above.

At each toggle pulse, each stage of the register shifts a 1 or a 0 to the next stage. The last two stages (*IC4*) drive the EXCLUSIVE OR gate. Switches *S3* and *S4* connect the logic so that the shift register goes forward, backward, with a normal scale, or with an inverted scale. The computer repeats every 63 counts. While any short sequence appears to be a random train of binary words, the same sequence repeats every time. Selector switch *S6* holds the computer in any interrupted state until the user is ready to re-start the sequence.

Each of the six stages has two possible outputs: a true or Q and the complement or not Q output. Thus there are twelve outputs which are selected by *S13*, *S14*, and *S15*, shown in Fig. 4 so that three signals are supplied to the tone generator.

Tone Generator. The circuit shown in Fig. 5 is basically a unijunction transistor oscillator (*Q5*) whose frequency is determined

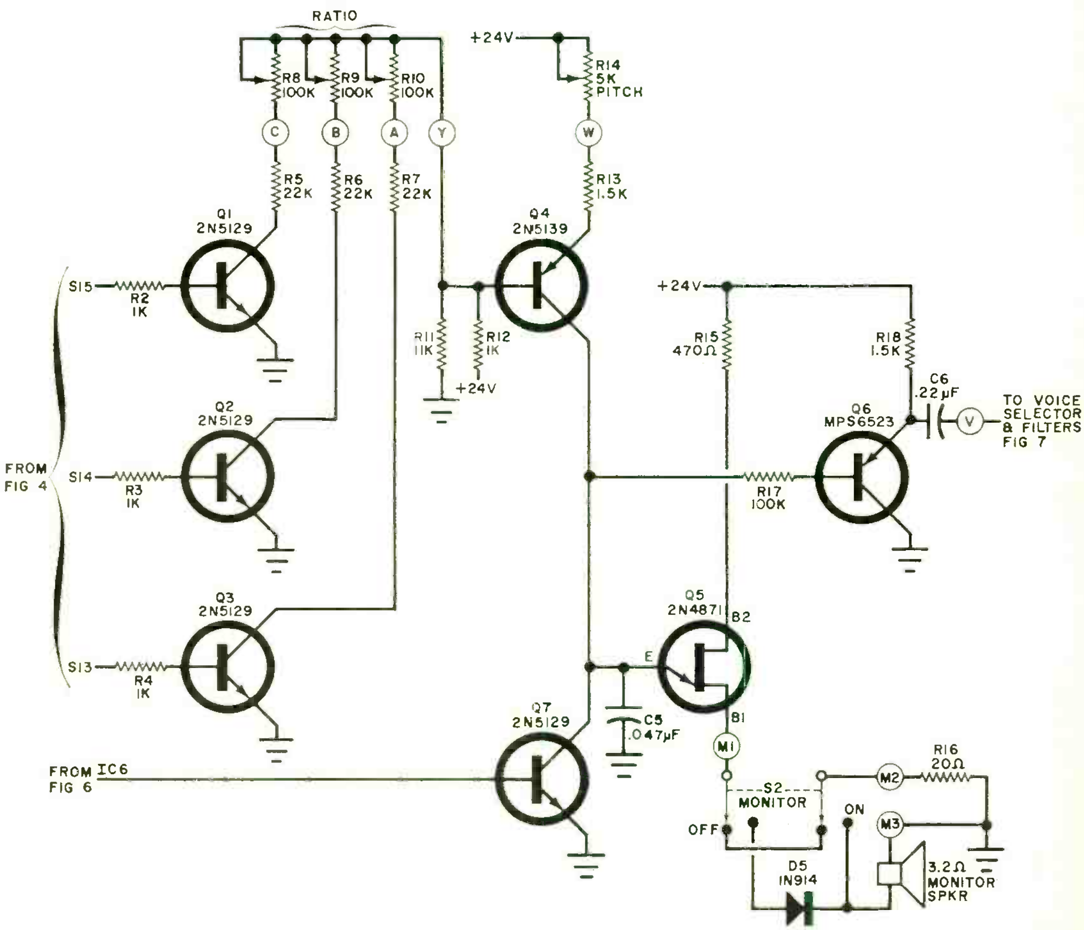


Fig. 5. The tone generator consists of a UJT oscillator whose frequency is dependent on the current flowing through Q4. This in turn is determined by the pitch control and operation of Q1 through Q3.

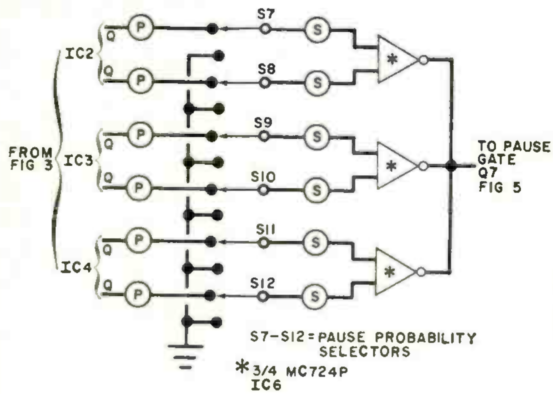


Fig. 6. Pause gate is an arrangement of two-input gates having a common output. The presence of signals on six input lines determines when there is an output.

by the value of *C5* and the collector current of *Q4*.

Transistors *Q1* through *Q3* cause the base voltage of *Q4* to vary in accordance with the signals selected by *S13*, *S14*, and *S15*. The effect of the signals on *Q4* is determined by the collector loads on *Q1* through *Q3*. These are potentiometers *R8* through *R10*. Normally, one control is set near maximum, one at the midpoint and the other near minimum to get a weighted average and provide a wide spread of tonal values. The three ratio potentiometers permit an infinite variety of tonal forms for each of the basic sequences.

Pitch is controlled by *R14*, which, when combined with the tone-shifting base voltage applied to *Q4*, determines the frequency of oscillation. Resistor *R17* and transistor *Q6* form a buffer amplifier having a low-impedance output for the voice selector without loading the UJT oscillator.

Pauses are provided by *Q7*, which shorts out *C5* and prevents a tone from being generated when a pause is desired.

The monitor speaker is switched in and out by *S2* while diode *D5* insures the same pitch whether the speaker is used or not. The speaker responds only to tone and pause sequences and is not affected by the sustain, attack, decay, and volume controls. However, the volume on the monitor is sufficient for practice sessions.

Pause Gate. As shown in Fig. 6, the pause gate consists of three two-input gates (*IC6*) arranged so that a logic 1 on any input allows the tones to be produced (through *Q7*). The six inputs come through selector switches *S7*

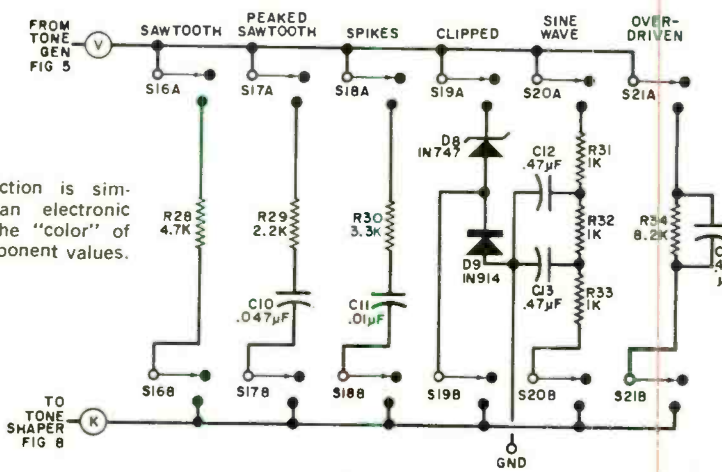
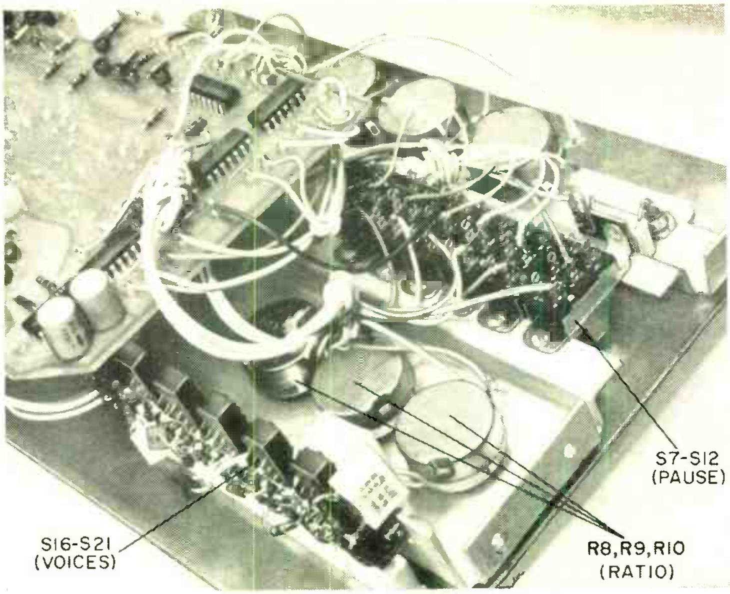
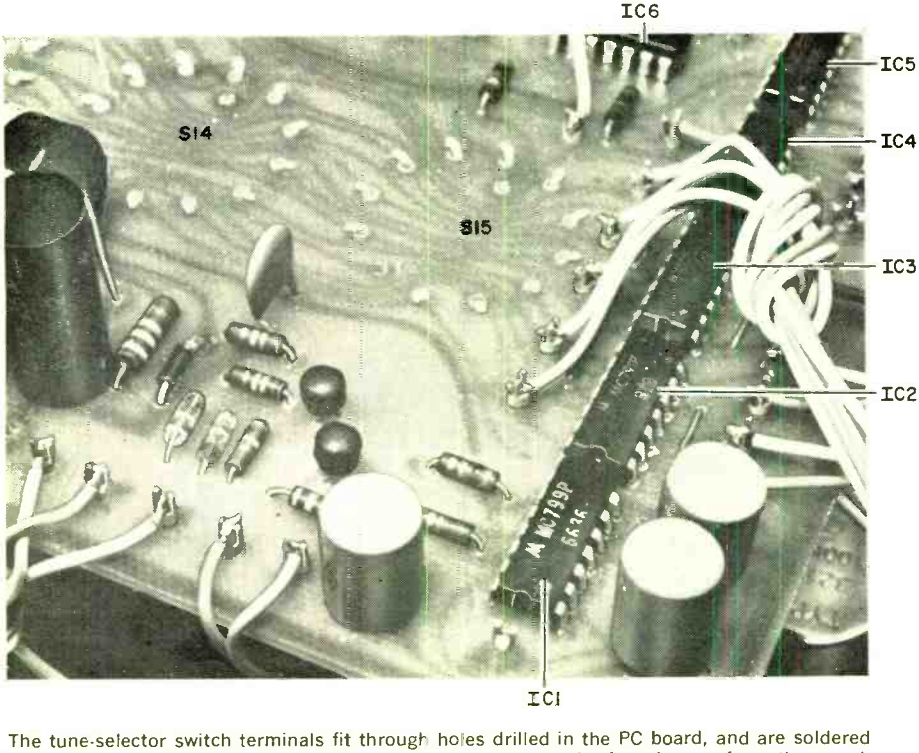


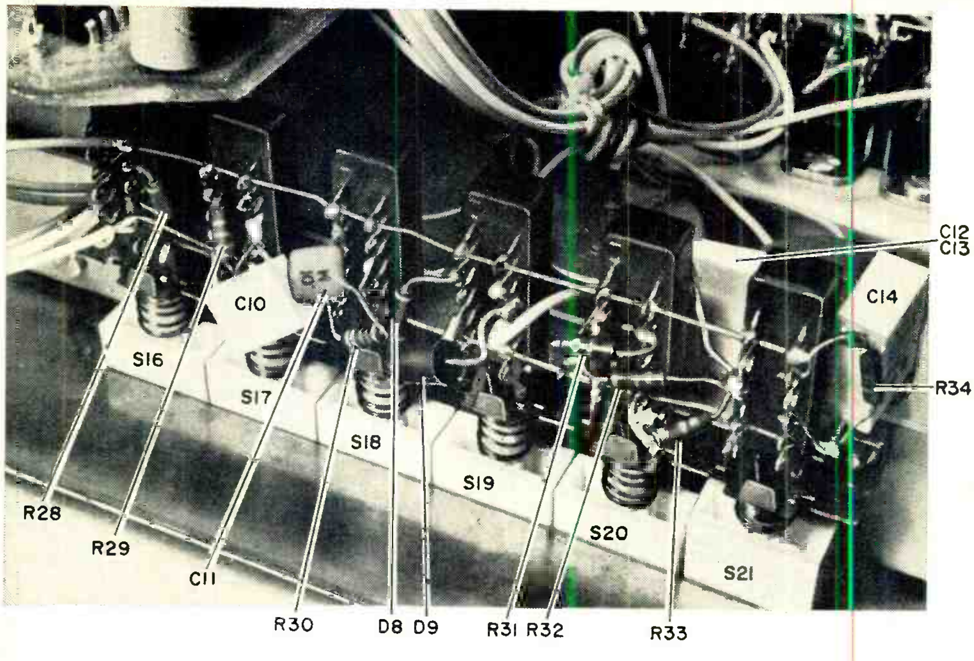
Fig. 7. Voice selection is similar to that of an electronic organ. To change the "color" of any voice, vary component values.



Although any mechanical arrangement can be used, the prototype was assembled to the front panel with a set of brackets and the potentiometer mounting hardware. The PC board is supported by the three tune-selector switches.



The tune-selector switch terminals fit through holes drilled in the PC board, and are soldered to the foil side of board. The three switches then support the board away from the panel.



The six voice switches are mounted on their own bracket with other components attached directly. The switch combination should be such that only one switch can be operational at any time.

through *S12*, which provide either a Q or not Q signal, the latter being ground. If all the switches were grounded, there would be no tone generated since the common output would be high, saturating *Q7* and stopping the oscillation of the UJT circuit. If any five switches are grounded, the circuit plays about half the tones, with blanks or pauses at random intervals. With four switches grounded, ¾ of the tones are sounded; while grounding any three switches drops one note in eight (on the average). The combination of switches used determines the positions of the pauses. Thus, there are 15 different ways to eliminate every fourth note on the average and 20 different ways to play the computer with an average of one note in eight missed.

Voice Selector. The circuit shown in Fig. 7 is controlled by a six-station interlocked pushbutton assembly (S16 through S21). The switches determine the waveform of the tone produced: sawtooth, peaked sawtooth, spiked, clipped, rough sinusoid, or overdriven. The filters suggested here were chosen for economical purposes; filters such as those found in electronic organs may be used to obtain other tonal qualities.

Tone Shaper. The tone shaper (see Fig. 8) converts the filtered tones into individual notes. Transistor *Q10* is biased by *R39* and *R40* to act as a variable resistor which conducts both positive and negative portions of a waveform equally. This transistor acts as a shunt to ground from the output terminal.

The voltage across *C8* determines the operational mode of *Q10*. If this voltage is 6 or more volts positive (with respect to ground), *Q10* acts as a low resistance and shorts out the signal. If *C8* is grounded, *Q10* passes all the signal. Intermediate values of the control voltage result in a controlled output level.

The rate at which *C8* goes from a positive voltage to ground determines how fast the output amplitude rises (the attack time); the length of time that *C8* stays near ground determines the sustain; and the rate of discharge on *C8* determines the decay time. The final output varies greatly for various values of attack, sustain, and decay. With a moderate amount of all three, a violin effect is obtained. With sharp attack, short sustain, and long decay, the percussive sound of a piano or chime is generated. A long attack, long sustain, and very short decay provide a totally unreal sound similar to a recording being

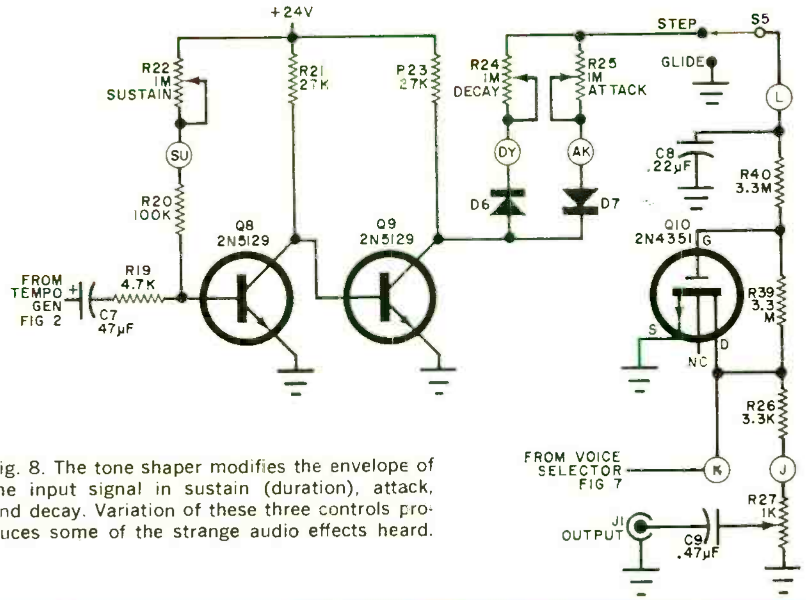


Fig. 8. The tone shaper modifies the envelope of the input signal in sustain (duration), attack, and decay. Variation of these three controls produces some of the strange audio effects heard.

played backward. Tremolo effects are obtained when the decay is set to overlap into the next tone, producing a "waa-waa". With *S5* in the glide position, *Q10* is disabled and the sound is similar to that of a bagpipe.

Transistor *Q8* is a monostable stage providing the sustain effect. Its output is controlled by *R22* and is inverted by *Q9*. The output of *Q9* is routed to *C8* for the attack effect or *R24* for decay.

Power Supply. The circuit of the power supply is shown in Fig. 9. It generates 24 volts dc for the tone generator circuit and 3.6 volts dc for the digital logic circuits.

Construction. An etched and drilled PC board is available commercially (see Parts List of Fig. 1) or you can make your own from a foil pattern that can be obtained by sending 25¢ to Editorial Department, POPULAR ELECTRONICS, 1 Park Ave., New York, NY 10016.

Install the components on the board as shown in Fig. 10. Install the five jumpers next to the IC's using insulated sleeving on the two jumpers toward the center of the board. You may use PC terminals for the external connections to the board.

To save a lot of individual wiring, switches *S13* through *S15* are mounted directly on the

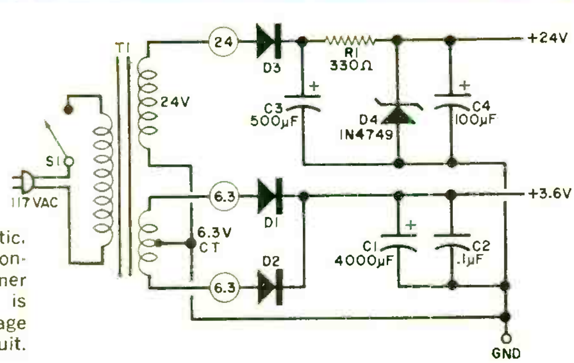


Fig. 9. As shown in the schematic, the power supply is quite conventional. The 24-volt supply has a zener diode regulator. The other side is not regulated since only the voltage level is of concern in the circuit.

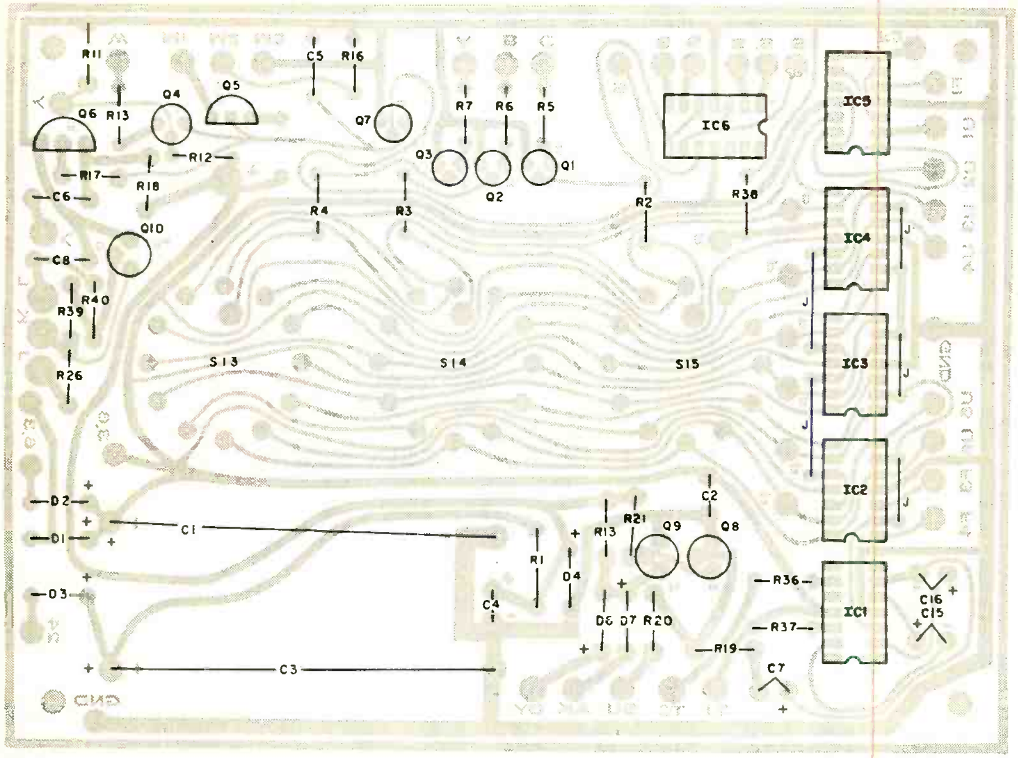
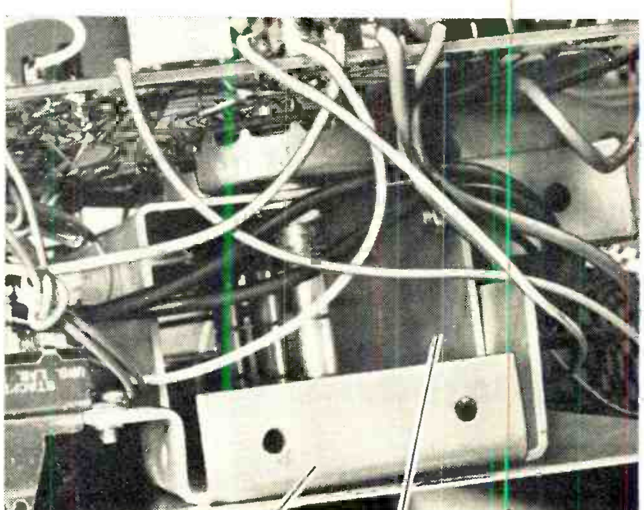


Fig. 10. Component installation. Unfortunately, the actual size foil pattern is too large for the page.

foil side of the board, with the switch terminals inserted through the board. The inserted terminals may be crimped and fastened to the component side of the board with epoxy cement; then solder them to the pads on the foil side. A small wire jumper at the common terminal of each switch simplifies the final assembly.

When installing the components, use a low-wattage soldering iron and fine solder, and observe the polarities of all components. Several different basing schemes are used on the



Author used a set of brackets and subchassis to assemble prototype. With some ingenuity, any other mechanical arrangement can be used.

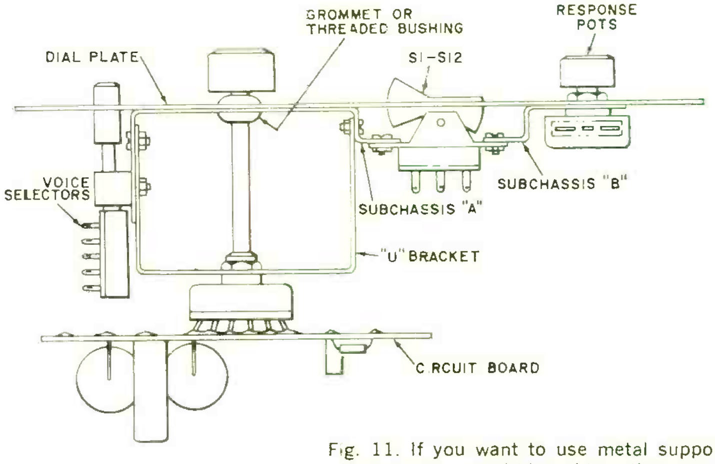


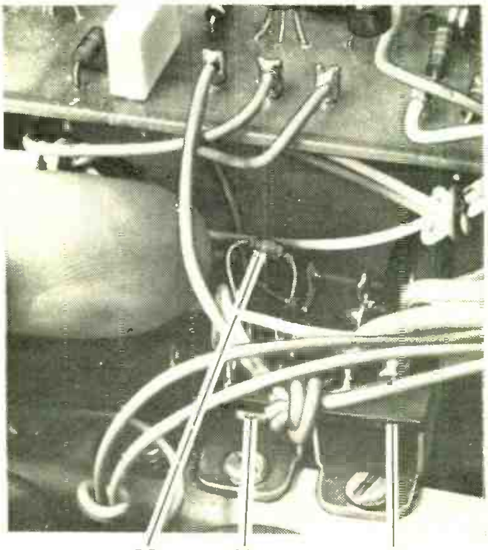
Fig. 11. If you want to use metal supports, this drawing will give you a good idea of how they are used and placed.

transistors so be sure you get them installed properly.

Transistor *Q10* can be damaged by careless handling. To install this component, wait until all the other parts have been mounted on the board. Do not remove the shorting ring that comes with the transistor until you are ready to install it. Just before installation, wrap several turns of bare wire around the leads at the case, remove the shorting ring, and turn the substrate lead up (it is left unconnected). Install the transistor using a low-power soldering iron (not a gun). Once it is in place, remove the shorting wire.

Two subchassis brackets and a larger U-shaped bracket are used in the final assembly (see Fig. 11). The dialplate is secured to the brackets using the potentiometer hardware. The transformer is mounted wherever convenient. The bottom panel supports the speaker.

To avoid wiring confusion, it is best to use several colors of wire and group them into harnesses by tieing them or slipping them through lengths of sleeving.



In most cases, components directly associated with a switch are mounted on the switch terminals.

Preliminary Checkout. Double check all wiring, install the various knobs, identify the detents on the switches, and use some form of lettering to mark all controls and switch positions.

Plug the unit in, turn on switch *S1* and measure both supply voltages to make sure they are correct. Place the monitor switch (*S2*) in the ON position and set *S6* to PLAY. Set any three pause select switches (*S7* through *S12*) up and the other three down. The Psych-Tone should start to compose. Connect an external audio amplifier and speaker to *J1* and note the effects of the voice selectors (*S16* through *S21*) and all other controls.

There are no operating rules. Any and all of the 28 operating controls can be used in any sequence to produce any desired effect. —30—

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The QRP Thing

BATTERY-OPERATED 40-METER TRANSMITTER

BY HANK OLSON, W6GXN

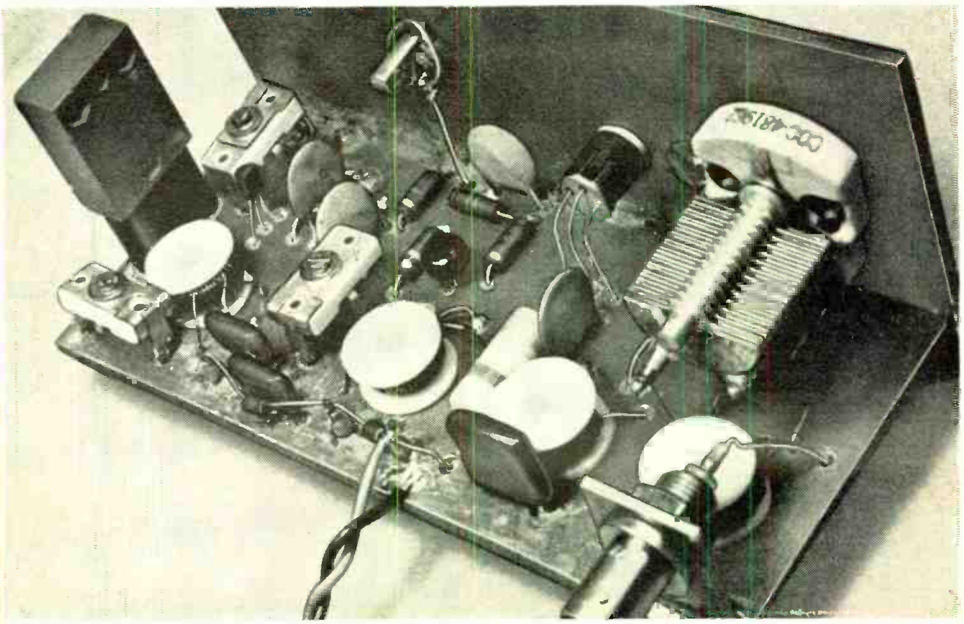
This solid-state amateur radio transmitter overcomes some of the evils of low-power transistorized designs—chirpy keying and plenty of harmonic radiation. Through the use of a FET crystal-oscillator and ferrite toroid core coils, this transmitter puts out a clean signal and has been used by the author on 7135 kHz to work most of the West Coast.

THERE HAS ALWAYS been an interest in low power operation among radio amateurs. During the first days of high-frequency radio, the very early QRP rigs were low-powered because the more powerful tubes were either rare or too costly. Even after the arrival of "war surplus" and a 100-watt tube became cheaper than a new 3Q4, there was a continuous stream of home-built QRP rigs—considered quite fashionable.

Most new QRP rigs are transistorized and therefore capable of low battery drain.[1,2,3,4,5,6,7] Such rigs run easily for long periods of time from inexpensive dry batteries or from a 12-volt auto battery.

Pretty Good, But! A rather surprising percentage of transistorized QRP rigs use crystal oscillators with designs that leave much to be desired. In fact, many of the circuits either key the oscillator or drive the output transistor directly from the crystal oscillator—both acknowledged to be relatively poor circuit practices.

Pre-World War II ham operators will recall some of the simple crystal-oscillator transmitters similar to the famous 6L6 Tri-tet circuit. These transmitters used a #49 incan-



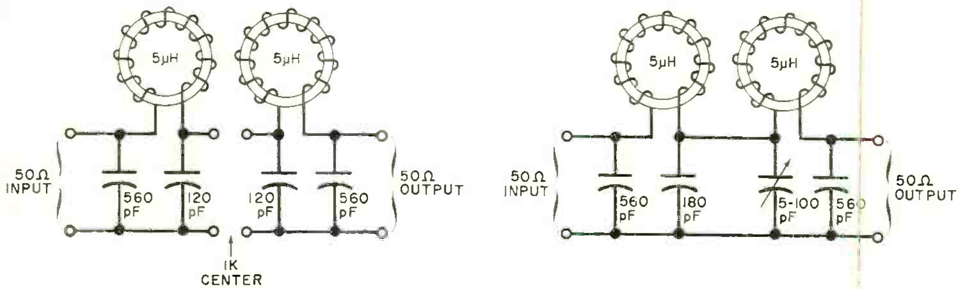


Fig. 1. A double pi-network was designed to be used with this transmitter. At the left, note that an untuned pi-network can be easily constructed using commonly available parts values to operate at 40 meters with 50 ohms input and 1000 ohms output. Two of these pi-networks placed back-to-back present the ideal impedance. The operating Q was chosen to be about 10.

descent bulb in series with a crystal as a fuse to prevent cracking the quartz crystal due to excessive currents. Radiating directly from a crystal oscillator—and keying it to boot—was bad practice in that era, and it is *still* bad practice in 1971. The only consolation is that a chirpy 2N3053 single stage running at 100 mW input isn't causing as much interference as a chirpy 6L6 running at 50 watts!

Most QRP crystal oscillator designs examined by the author used bipolar transistors. The bipolar transistor does not make a good crystal oscillator—except perhaps for use with crystals that are cut for series-mode operation. This is because of the low impedances associated with a bipolar transistor.[8] In many QRP circuits, the crystal either doesn't oscillate reliably, or does so at a frequency considerably lower in frequency than it is marked —since most amateur band crystals are ground for use in parallel resonant circuits (around 32 pF).

FET Crystal Oscillator. The QRP transmitter discussed in this article solves several of the problems inherent in circuits published in the past. This circuit uses an FET in a standard Colpitts configuration that presents 32 pF to the crystal. Amateur band crystals in this circuit oscillate at the frequencies marked. Furthermore, the low drive assures thermal stability of the crystal to reduce frequency drift. Since the crystal oscillator stage is not keyed, chirping is no longer a problem. Keying is accomplished in the emitter of the second (driver) stage which is running in class A. The final stage of this QRP transmitter runs at zero bias—or class C—and only

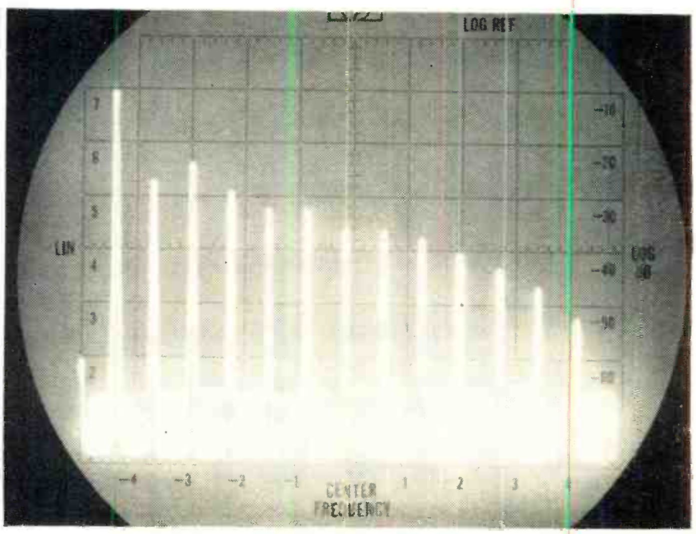
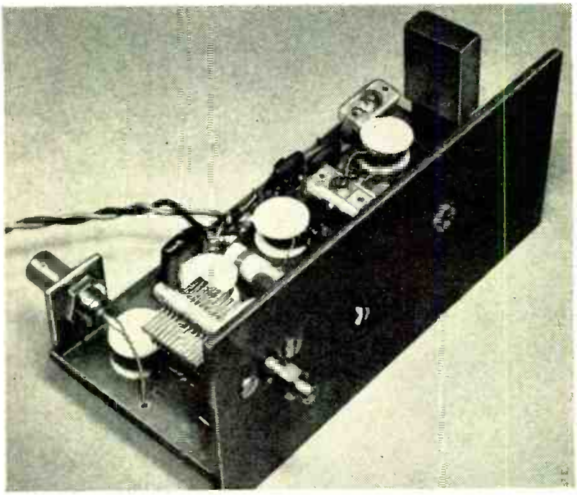


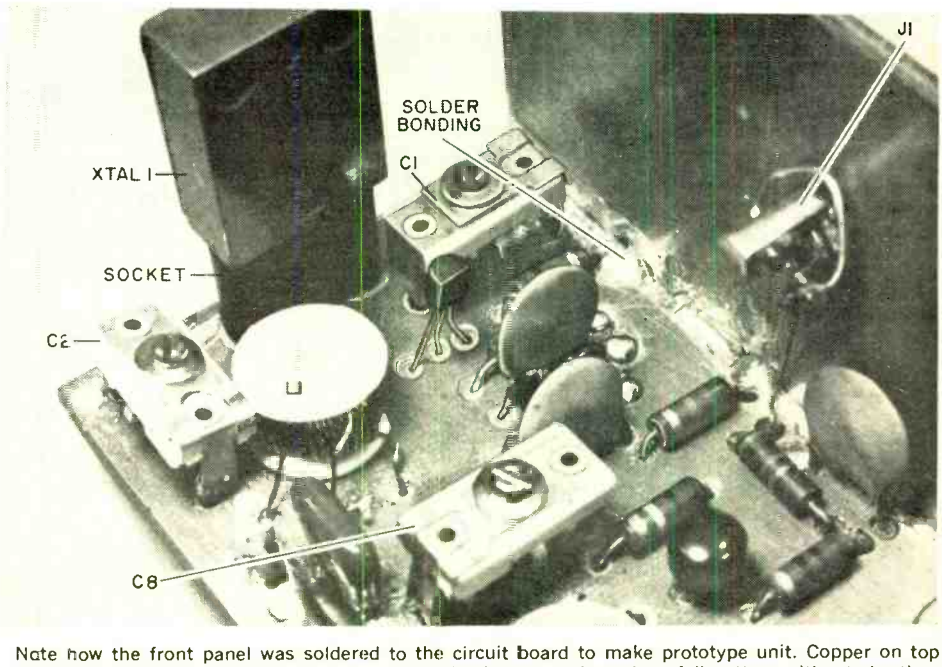
Fig. 2. This is the display of output from the 2N3053 stage without dual pi-network. Note the excessive generation of harmonics that would go right into the antenna. Each horizontal division is 10 MHz and the 3rd harmonic is only 14 dB down. With dual pi-network above in circuit, the 3rd harmonic was suppressed about 55 dB.

conducts current when its base-emitter junction is forward-biased by positive swings of the r-f drive.

Those familiar with transistor circuits are probably now reading this with raised eyebrows. Certainly the most nonlinear gadget in the history of ham radio is a transistor operating in class C. After all, driving a diode (base-emitter junction) into forward conduction is reminiscent of antique 100-kHz calibrators, where a diode was inserted in the output to enhance harmonic production. Since the final of the QRP transmitter does have such a large harmonic content, it is necessary to insert an output network having a highly effective operating Q. This is no real burden in design since the output impedance of our transistor final is quite low and a two-section matching network is easier to realize than a single-section network.


For a front panel for transmitter, prototype had a second sheet of double-faced copper clad board.

A double-pi network is shown in Fig. 1. The point at which the two pi-sections interconnect was chosen to be 1000 ohms and the operating Q of each section was chosen to be 10. Since the input and output impedance are both 50 ohms, it is possible to show the effectiveness of this network on a spectrum analyzer—see Fig. 2. Note that the analyzer pattern shows the third harmonic at 21 MHz to be only 14 dB down from the fundamental when operating the collector directly into 50 ohms. A similar spectrum oscillogram taken with the double-pi inserted in the circuit would



Note how the front panel was soldered to the circuit board to make prototype unit. Copper on top of board must be removed so that component leads can go through to foil pattern without shorting.

PARTS LIST

C1,C2,C8,C14—5-100-pF trimmer capacitor
C3,C6—0.047-µF capacitor
C4,C7,C9,C11—0.01-µF capacitor
C5—120-pF capacitor
C10—0.22-µF capacitor
C12,C15—560-pF capacitor
C13—180-pF capacitor
J1—Normally closed miniature phone jack
L1—Coil: 34 turns #24 enamelled wire: 5-turn link*
L2—Coil: 34 turns #26 enamelled wire: tap at 5 turns; 3-turn link*
L3,L4—Coil: 34 turns #24 Formvar*
Q1—MPF102 or HEP802 transistor
Q2—2N3641 or HEP53 transistor
Q3—2N3053 transistor
R1—1-megohm, ½-watt resistor
R2—1000-ohm, ½-watt resistor
R3—10,000-ohm, ½-watt resistor
R4—1500-ohm, ½-watt resistor
R5—10-ohm, ½-watt resistor
R6—100-ohm, ½-watt resistor
RFC1—47-µH choke
XTAL1—7.135-MHz crystal
Misc.—Ferrite beads*, heat sink for Q3, 1000-pF feedthrough capacitor (3), BNC connector, suitable copperplated PC board, crystal socket, mounting hardware, etc.

*The following are available from Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607: T-50-6 toroid coil forms at 50¢ each; packet of ferrite beads at $2.

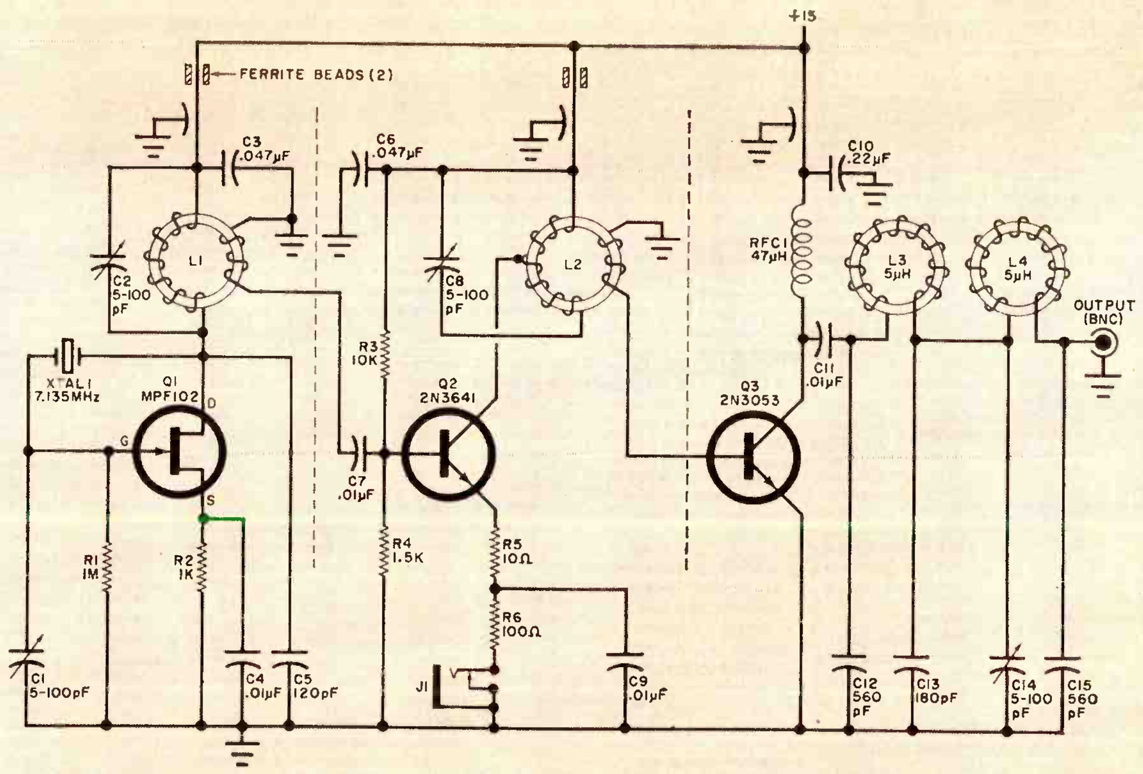
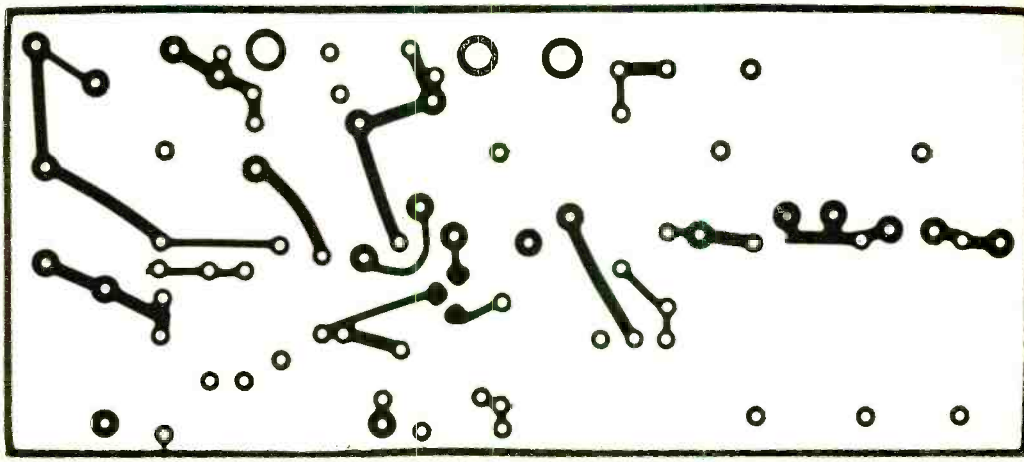


Fig. 3. Final circuit for the QRP transmitter accomplished all of the author's design objectives—better keying and less harmonic radiation.



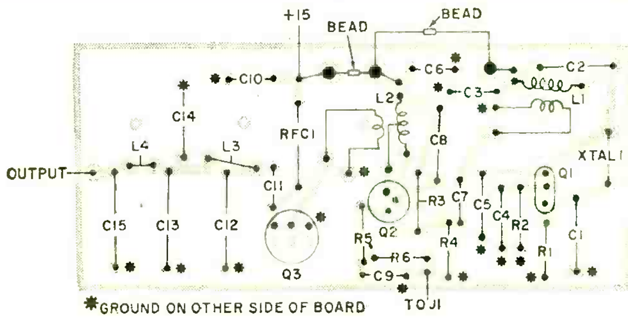
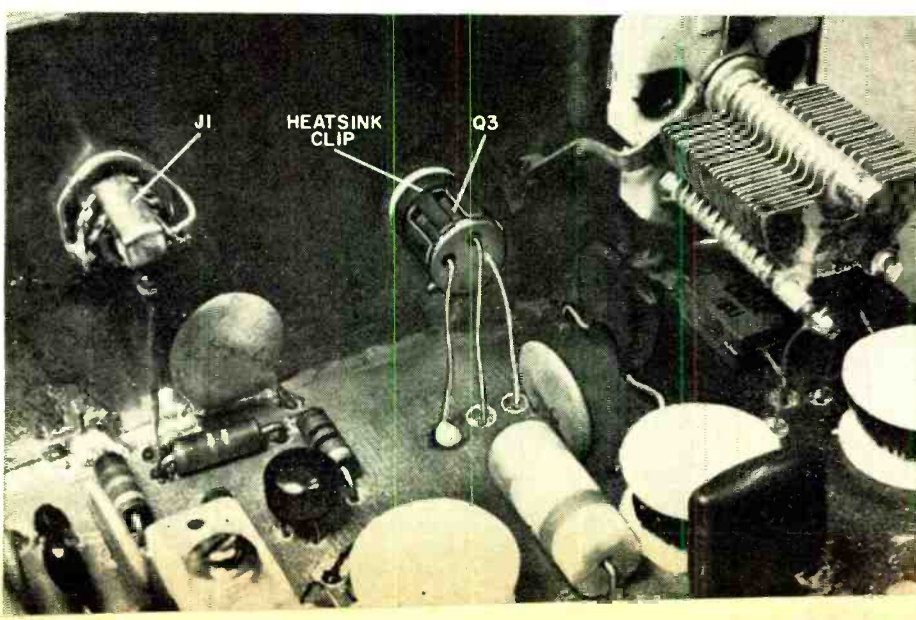


Fig. 4. Above is printed circuit foil pattern for underside of the double-faced board. Parts placement is shown at left. Note that this is view looking up through both copper foils. Terminations that are not marked with an asterisk go through the top side of the board and are soldered to remaining etched foil pattern.

show the only harmonic visible (second) to be 55 dB down from the fundamental.

After experimentation, the final circuit for the QRP rig is shown in Fig. 3. The overall circuit is straightforward and uses readily available components with the sole exception of the two toroids, *L1* and *L2*. If any coil types other than the toroids are substituted, considerable additional shielding will be required.

The heat sink which holds transistor Q3 is fastened by a bolt through the front panel. Note how two of Q3's leads go through circuit board to foil pattern while the third is soldered to the top.



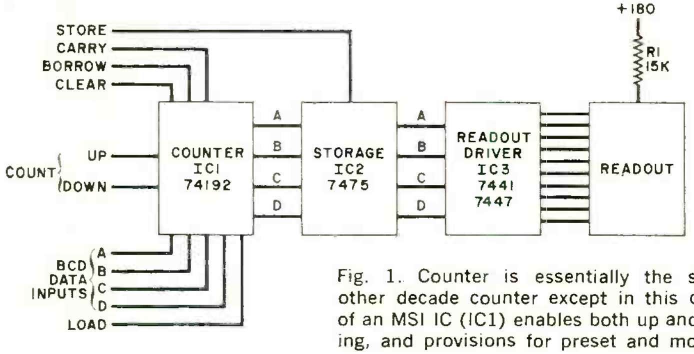


Fig. 1. Counter is essentially the same as any other decade counter except in this case, the use of an MSI IC (IC1) enables both up and down counting, and provisions for preset and modulo change.

PARTS LIST

IC1—74192 synchronous 4-bit up/down counter
IC2—7475 4-bit bistable latch
*IC3—7441 BCD-to-decimal decoder**
*R1—15,000-ohm, ½-watt resistor***
V1—Readout tube (Burroughs B-5750, Amperex ZM-1000, or similar)
Note—The following are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216: etched and drilled G-10 fiberglass PC board (#UCB) at $2.15 postpaid; complete kit of parts including PC board (#UCN-1) at $25.00 plus postage and insurance for 6 oz.
**A 7447 BCD-to-seven-segment decoder/driver must be used here if 7-segment readout is used. The PC board will have to be changed to accommodate different IC.*
***Controls readout tube brightness. May be between 10,000 and 22,000 ohms, as desired.*

speed—as more and more uses for the DCU are found, counting frequencies are steadily increasing.

The Ultimate Counter, with a maximum counting speed of 32 MHz, was designed to solve all of the above problems. This counter has a number of new features (see Fig. 1) which are made possible by the use of a new integrated circuit (the 74192), the first medium-scale integration (MSI) device to be used in an experimenters' construction project.

The 74192 IC has up and down inputs, four extra data inputs to preset the counter to any state, and facilities for clear, carry, and borrow functions. The clear input is completely independent of the count and forces the outputs to a low state when it is activated. Several counters can be cascaded by connecting the borrow and carry outputs to the up and down inputs of the next counter. The four data inputs can be used to preset the counter to any desired number by feeding the respective BCD (binary coded decimal) signal into these inputs and activating the load line.

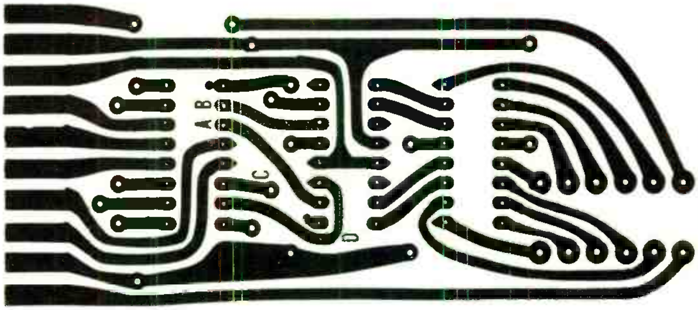
There is no prefix on the integrated circuit type number since the device is made by several different manufacturers who use their own prefixes.

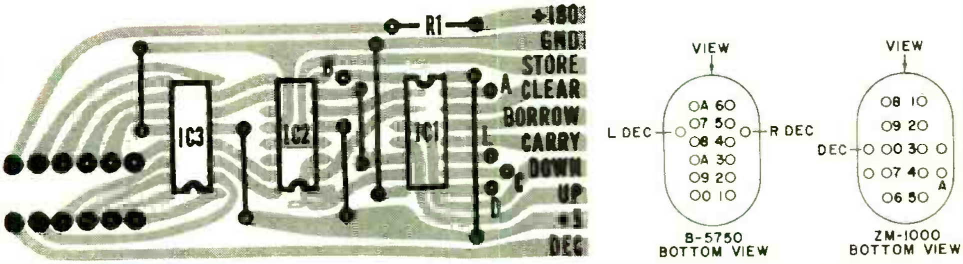
Storage. This stage does not add anything to the performance of the counter, but makes it more enjoyable to use. In many instruments, the measuring cycle can be from a tenth of a second to several seconds. During this time, an annoying blur of digits appears on the readout. This effect is removed by storing the BCD data from the input counter and passing it on to the readout on command when the counting cycle is finished. In this way, the readout remains stationary until the command is given and the readout switches to the new value. If this feature is not wanted, the outputs of the counter IC can be connected directly to the driver IC, with the storage IC omitted.

Readout Driver. The driver stage is either a 7441 IC (for a Nixie® tube readout) or a 7447 IC (for a 7-segment readout).

Construction. The foil pattern for the Ultimate Counter, using a Nixie tube readout, is shown in Fig. 2. Component and jumper installations are also shown. The foil pattern will have to be altered if the 7447 IC is used for 7-segment readout. The power supply shown in Fig. 3 can be used to supply several counter boards.

Fig. 2. Actual-size foil pattern and component installation for Nixie-tube operation. The foil pattern for IC3 will have to be revised if a 7-segment driver is to be used.





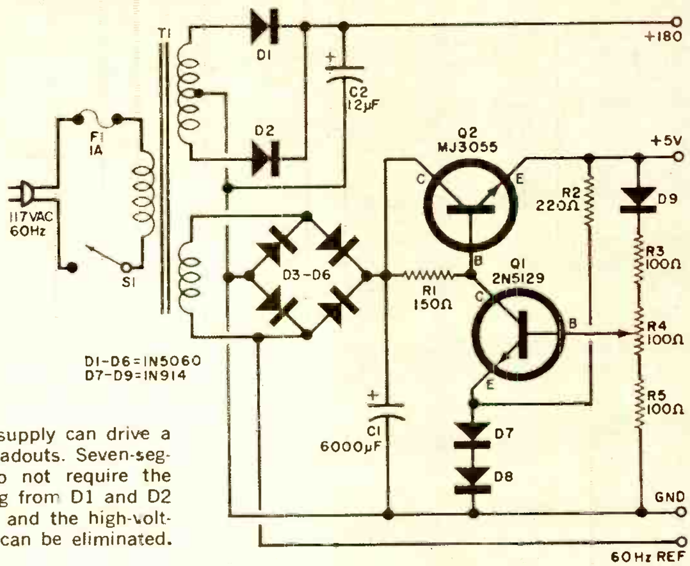


Fig. 3. The power supply can drive a number of Nixie readouts. Seven-segment indicators do not require the high voltage coming from D1 and D2 therefore they, C2, and the high-voltage winding of T1 can be eliminated.

PARTS LIST
POWER SUPPLY

C1—6000-µF, 10-volt electrolytic capacitor
C2—12-µF, 250-volt electroylic capacitor
D1-D6—1A, 400V PIV silicon rectifier (IN-5060 or similar)
D7-D9—1N914 diode
F1—1A-fuse
Q1—2N5128 transistor
Q2—MJ3055 transistor (Motorola)
R1—150-ohm, ½-watt resistor
R2—220-ohm, ½-watt resistor
R3,R5—100-ohm, ½-watt resistor
R4—100-ohm, PC-type trimmer potentiometer (IRC X-201 or similar)
T1—Power transformer: secondaries: 6.3V at 1A, 300V CT at 25 mA
Misc.—Heat sink for Q2, spacers, mounting hardware, etc.
Note—The following are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216: etched and drilled PC board #169-PB at $2.45 postpaid: complete kit of parts including PC board #169-C at $11.55 plus postage for 4 lb.

cuits from discrete elements: transistors, resistors, capacitors, diodes, etc.

The purpose of this article is to provide information needed to breadboard IC logic element equivalents, or near equivalents. "Equivalent"—as used here—refers to the function and not the configuration of the IC and discrete circuits.

In this first of a two-part story on resistor-transistor logic (RTL), attention is focused on logic gates. (The glossary explains the distinction between the three fundamental types of digital logic systems—RTL, DTL, and TTL—and provides definitions for the various technical terms used in this article.) Installment number two will deal with the more sophisticated toggled logic circuits, including the JK flip-flop.

Virtually every RTL element consists of some form of logic gate which operates in much the same manner as a common relay. The gate requires an input activating force and a two-state (on/off, high/low, or logic 1/logic 0) output. Only two output states are necessary for digital circuits to communicate in their two-digit, or binary arithmetic, language. Consequently, the basic elements of digital systems are quite simple.

Compared to the 0-to-9 decimal system of arithmetic, however, binary arithmetic requires a tedious number of operations to perform the same function and process the same information. The extra operations, of course, require extra logic elements which, in turn, give all digital equipment the appearance of being complex.

The actual simplicity of a digital logic element can be seen in the two-input IC logic gate shown in Fig. 1. If only one stage of this circuit is considered, it is the configuration of an *inverter*, or one-input gate, in an integrated circuit. This gate could not be simpler, consisting of a single transistor and its associated

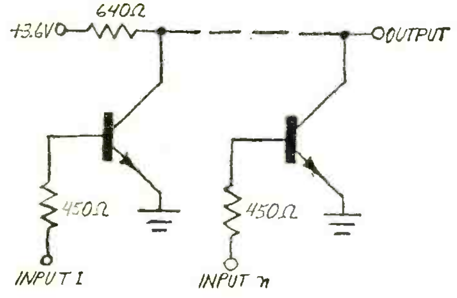


Fig. 1. N-input integrated circuit gate.

base resistor. A hex-inverter IC would contain 6 such inverters, all connected to the power source through a common 640-ohm collector load resistor. (Note: Integrated circuit designers have chosen 450 ohms and 640 ohms for the base and collector load resistors, respectively. These values give the circuit optimum fan-in and fan-out. The 450- and 640-ohm values used inside IC's are not commonly available in discrete component form; when you breadboard your elements, you would use 470- and 680-ohm resistors. These will work adequately.)

The transistors in all RTL integrated circuits are silicon npn types with characteristics similar to discrete computer-type switching transistors. All RTL IC's operate from a power source of 3.6 volts within a maximum tolerance of ten percent.

When breadboarding any RTL element, keep in mind that a computer-type transistor need not have a linear transfer characteristic since it is never operated in a linear fashion. It is either completely cut off or fully saturated. However, it must have certain other characteristics: excellent high-frequency response; comparatively high saturation current gain; and 0.2 volt or less collector-to-emitter saturation potential. The latter is important because when the output of one gate is connected directly to the input of another gate, the output potential of the first transistor, when saturated, is sufficiently near ground potential to insure that the second transistor is fully cut off.

A one-input gate is most commonly referred to as an inverter because its output is 180° out of phase with its input. In terms of positive computer logic, when the input is at a logic 1, the output is at a logic 0, and vice versa (logic 1 is the complement of logic 0). In terms of negative computer logic, the 0's and 1's change places for the on or off state of a given transistor.

It is simpler to follow positive computer logic where a logic 0 is equal to ground or near ground potential because the logic designation coincides with the signal level. As far as logic is concerned, however, it makes no difference whether logic 0 is represented by a near-ground potential or by some potential significantly removed from ground. If you think of a logic 0 as represented by a cut off transistor, and a logic 1 as represented by a saturated transistor, then negative logic can be followed as easily as can positive logic.

The schematic diagram of Fig. 1 shows how simple it is to provide additional inputs to the

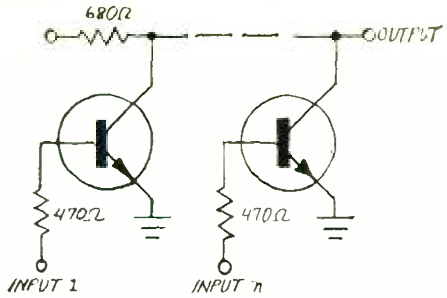


Fig. 2. N-input discrete-component logic gate.

logic gate. The collector load resistor remains the same for each additional input stage. Theoretically, at least, IC designers could go on adding inputs in this fashion until the total accumulated leakage current became excessive. In easily available IC's, four inputs—in a quad arrangement—are the most you can get. Within reasonable limits, adding inputs has no significant effect on the fan-in and fan-out factors of a gate.

There is nothing mysterious about resistors and transistors on an IC chip. They function the same as their discrete counterparts. So, you can easily assemble an inverter, a two-input gate, an *n*-input gate, etc., using discrete components alone. (The circuits presented from here on are designed to operate at speeds up to 100,000 Hz, sufficient for experimental purposes. Digital equipment used in science and industry, of course, becomes practical only because it can operate at speeds in the MHz range.)

Figure 2 shows how you can breadboard logic gates with discrete components. Readily available resistor values are somewhat greater than those conventionally used in integrated circuits, but they are close enough for the most part—especially if you do not attempt to work your discrete-component setups close to maximum fan-out. But when working with critical circuits, you shouldn't load your circuits too heavily in any case.

Almost any high-speed, computer-type silicon npn switching transistor can be used in your circuit setups. A good example of such a transistor is the 2N2475 and HEP56. If you are in an area where surplus parts stores are located, you might be able to pick up quite an assortment of silicon switching transistors at bargain prices.

In the absence of computer-grade transistors, you might try using any high-frequency silicon npn transistors you have around. But remember to run the input up to where the transistor is well into saturation, and check the collector-to-emitter potential with a meter. If the reading obtained is 0.2 volt or less, chances are you can use the transistor in digital logic-gate service.

Being able to expand a gate is particularly useful when circuits are being assembled on your workbench. The circuit in Fig. 3A is an *expander*, resembling an inverter or one-input gate with the exception that it has no collector load resistor. Figure 3B shows how an expander can be added to an IC inverter element to make a two-input logic gate. Simply connect the collector (output) of the expander circuit to the output of the inverter. The input to the inverter now becomes input 1 and the input to the expander becomes input 2. Note that the circuit is fundamentally identical to that in Fig. 1. In a similar manner, you can add an expander to a two-input gate to create a three-input gate, and so on.

Now, suppose you have a two-input-gate IC, you need a three-input gate, and you have no suitable transistor on hand to breadboard the expander. You can expand the two-input gate to a three-input gate by using a couple of germanium diodes as shown in Fig. 4A. The diodes can be 1N191 or HEP134 types—or any diode with similar characteristics.

The purpose of the diodes is to keep a logic signal at input 1 from entering input 2 and vice versa. Yet each diode allows the signal at its respective input to enter the IC left-gate input. (Note: Discrete and IC configurations can be identified by whether or not a circle encloses the transistors. Discrete transistors are enclosed in circles, while IC transistors

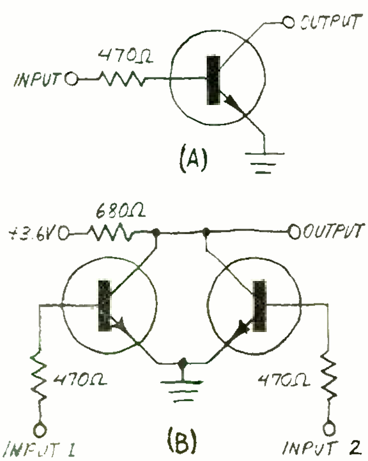


Fig. 3. Simple expander (A) adds inputs to gate (B).

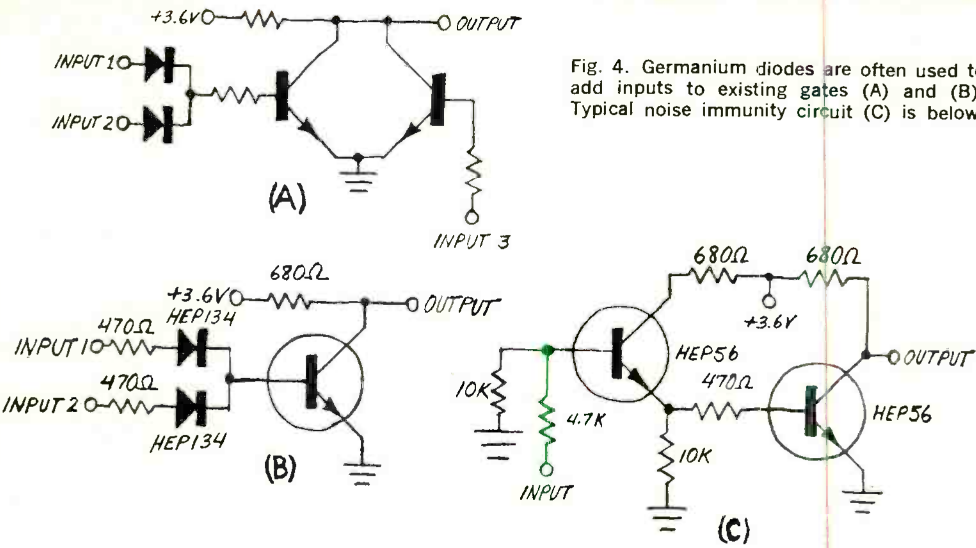


Fig. 4. Germanium diodes are often used to add inputs to existing gates (A) and (B). Typical noise immunity circuit (C) is below.

are not.) If you need a four-input gate, you can add a similar pair of diodes in the same manner to the input resistor on the second transistor.

There can be a 0.3-0.4-volt forward voltage drop across each diode, so it is not advisable to use diode expansion as part of the load in a maximum fan-out configuration. The transistor expander in Fig. 3A is not subject to this limitation.

On the other hand, if you are breadboarding a two-input gate using a pair of germanium diodes and a single transistor, as shown in Fig. 4B, you can often get around the voltage-drop limitation by using a *germanium* npn transistor (HEP641 or similar) in the setup. However, there are significant factors that must be taken into consideration here. First, germanium transistors can be operated in no more than a moderate temperature environment since they perform poorly or not at all at elevated temperatures. (The same, of course, applies to germanium diodes.) Second, the lower the required logic level, the lower the noise immunity of the circuit.

For those setups where noise pulses or spurious signals are a particular problem, the circuit in Fig. 4C can be of considerable value. This circuit gates with an input logic level of 3 volts but is unresponsive to input signals of 1.5 volts or less. Additionally, its fan-in is only about ten percent that of a gate with a conventional input.

From now on, logic symbols will be used in many of the schematic diagrams in this article. The logic symbols, with their equivalent electronic circuits, are given in Fig. 5.

A positive-logic NOR gate is a negative-logic NAND gate. From the point of view of positive logic, the gates described thus far are all NOR gates in which a logic 1 input to *either* input 1 or input 2 (or both) produces a logic 0 output.

The circuit in Fig. 6A is a conventional positive-logic two-input AND gate wherein *both* inputs must be supplied with a logic 1 signal to generate a logic 1 signal at the output. This setup requires two inverters and a two-input gate to bring the input and output signals into phase with each other. The small circles at the apices of the logic symbols indicate inversion, or a 180° phase displacement, between the input and output signals. Hence, two gates or inverters are needed to make the output and input signals of the same phase.

If you have only three inverters and no two-input gate available, you can breadboard a positive-logic AND gate with the aid of a pair of germanium diodes as shown in Fig. 6B. An AND gate, assembled with discrete components is given in Fig. 6C.

An AND gate requires two inversions so that logic 1 inputs provide a logic 1 output. Without the second inversion, we would have a NAND gate. In the NAND circuit, logic 1 inputs provide a logic 0 output. Given in Fig. 6D and in Fig. 6E are the logic diagram and discrete component schematic diagram for NAND gates.

In comparing the AND and NAND gates, note that a double inversion is equal to no inversion at all.

In the preceding logic-gate circuits, output

GLOSSARY OF DIGITAL LOGIC TERMS

ADDER: Switching circuit that combines binary information to generate the SUM and CARRY of this information.

AND: This Boolean logic expression is used to identify the logic operation where, given two or more variables, all must be logic 1 for the result to be a logic 1.

DTL (Diode-Transistor Logic): Logic is performed by diodes with transistors used only as inverting amplifiers.

EXCLUSIVE OR: A logic function whose output is 1 if either of the two input variables is 1 but whose output is 0 if both inputs are 1 or 0.

FAN-IN: A figure denoting the input power required to drive a logic element satisfactorily.

FAN-OUT: A figure denoting the power output of a logic element with respect to logic element inputs.

AND GATE: All inputs must have 1-level signals at the input to produce a 1-level output.

NAND GATE: All inputs must have 1-level signals at the input to produce a 0-level output.

NOR GATE: Any one input or more than one input having a 1-level signal will produce a 0-level output.

OR GATE: Any one input or more than one input having a 1-level input will produce a 1-level output.

HALF ADDER: A switching circuit which combines binary information to generate the SUM and CARRY. It can accept only the two binary bits to be added.

INVERTER: A circuit whose output is always 180° out of phase with its input. (Also called a NOT circuit.)

NEGATIVE LOGIC: Logic in which the more negative voltage represents the 1-state; the less negative voltage represents the 0-state.

NOISE IMMUNITY: A measure of the sensitivity of a logic circuit to triggering or reaction to spurious or undesirable electrical signals or noise, largely determined by the signal swing of the logic.

RTL (Resistor-Transistor Logic): Logic is performed by resistors. Transistors are used to produce an inverted output.

TTL, T^2L (Transistor-Transistor Logic): A logic system evolved from Diode-Transistor Logic in which the diode cluster is replaced by a multiple-emitter transistor.

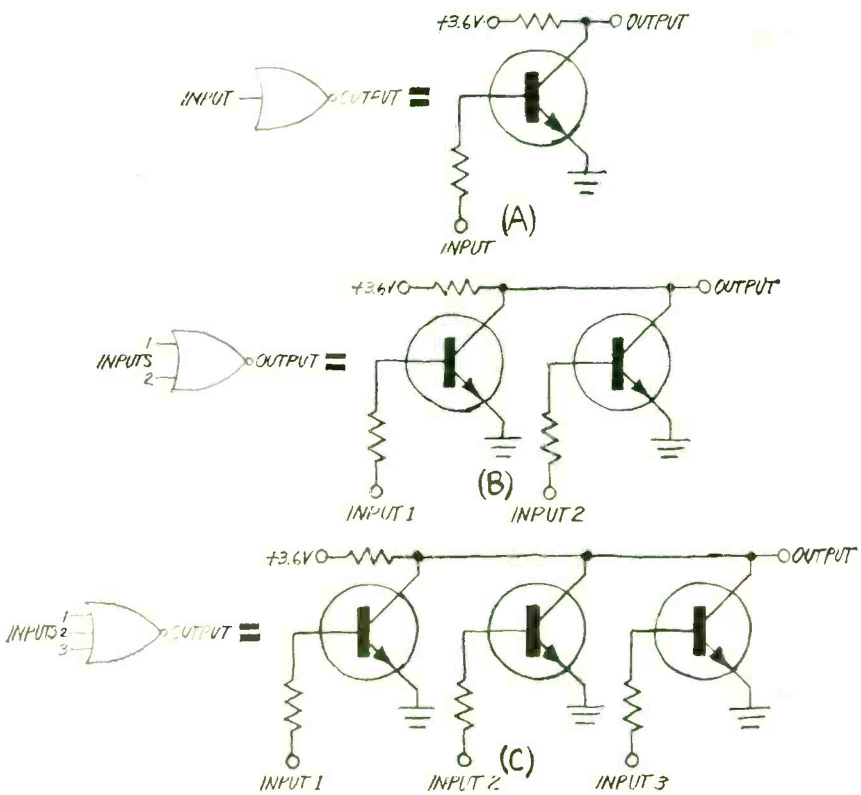


Fig. 5. Logic symbols (at left of each circuit) are generally used in logic flow diagrams.

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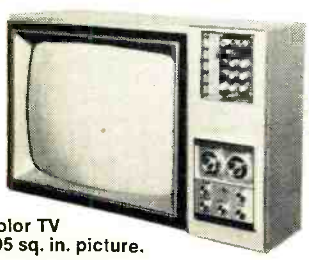

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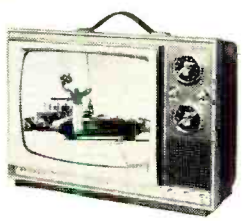

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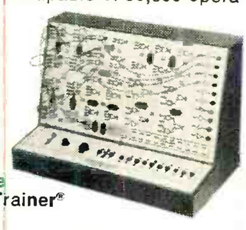

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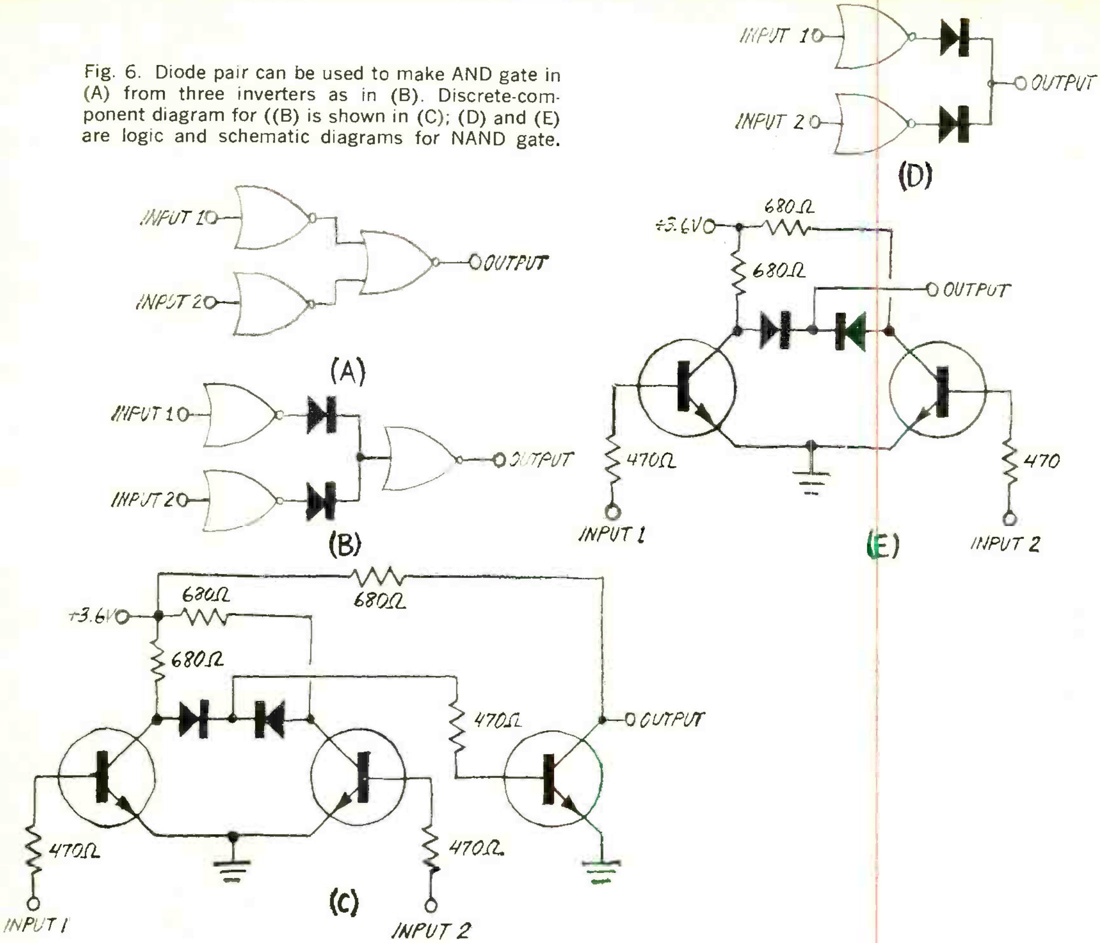


Fig. 6. Diode pair can be used to make AND gate in (A) from three inverters as in (B). Discrete-component diagram for ((B) is shown in (C); (D) and (E) are logic and schematic diagrams for NAND gate.

logic directly follows input logic. In the simple two-input gate, for example, a logic 1 at either of the two inputs produces a logic 0 output. Removal of the logic 1 input by sending the input to logic 0 produces a logic 1 output.

There are, however, applications where it is desirable to turn on one gate by applying a signal to one input and turn off the gate by applying a signal to the other input. Once such a circuit is energized, it will remain turned on even after the excitation signal is removed. It will also be unresponsive to succeeding turn-on signals. Similarly, once it is turned off, it will remain off and be unresponsive to subsequent turn-off signals. Such a device can be thought of as a "latch" and is known as an RS (for reset-set) flip-flop.

The fundamental circuit of a latch can be represented by a pair of inverters, with the output of one inverter connected directly to the input of the other as shown in Fig. 7A. Because inversion occurs in each inverter, it is obvious that when one side of the circuit is on, the other must be cut off. It is equally obvious that the on side must remain on and the off side remain off unless something is done to make the system change states. No provision is made to effect any such control in the simple circuit shown.

A more practical latch or RS flip-flop is shown in Fig. 7B. Here a pair of two-input logic gates is used. One input of each is used for the feedback, and the other is used for control. A logic 1 signal applied to input 1 sends output 1 to logic 0 and output 2 to logic 1. The circuit then remains in this state—held there by its own feedback and disregarding any further application or removal of turn-on signals—until a logic 1 signal is applied to input 2, at which time the output logic reverses itself.

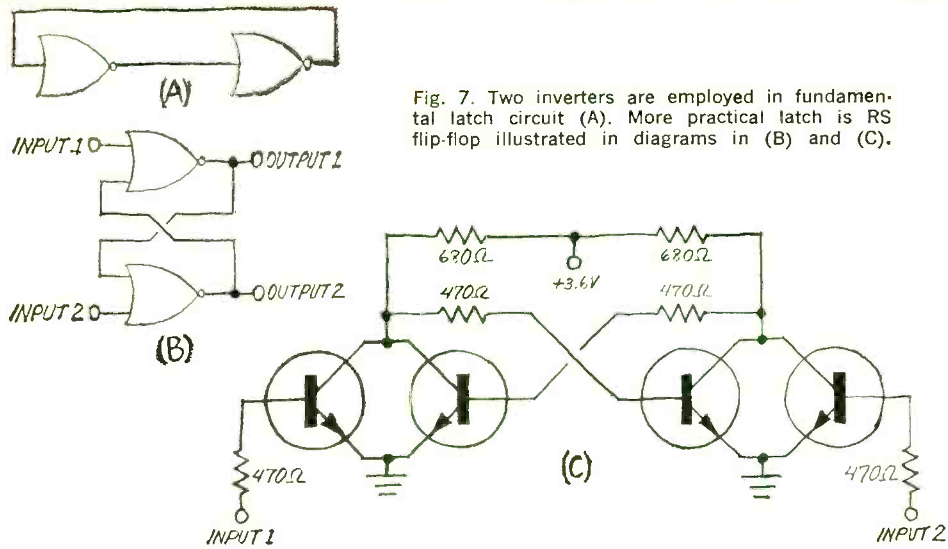


Fig. 7. Two inverters are employed in fundamental latch circuit (A). More practical latch is RS flip-flop illustrated in diagrams in (B) and (C).

Only a brief pulse at the proper input terminal is needed to trigger and latch the circuit in either state. The waveform of the control pulse is not especially critical. In fact, an RS flip-flop is often used to "shape" a logic pulse by converting it to a square wave with very steep sides.

If a logic 1 signal is applied to both latch inputs simultaneously, both outputs will go to logic 0. The final state of the latch will then depend on which of the two inputs is the last to be removed. Ordinarily, a latch is not operated in this mode; but if a particular setup calls for such operation, there is no reason why it cannot be employed.

The circuit in Fig. 7B is given in discrete-component form in Fig. 7C. Depending on what components you have available, you can breadboard a latch in several different ways. It can consist of a dual two-input gate IC, a pair of inverters in an IC (plus a couple of expanders), or four individual transistors if necessary.

If you need a latch circuit and have only a single pair of computer-type silicon npn transistors, or a couple of spare inverters in a hex-inverter IC, you can assemble the fundamental latch circuit in Fig. 7B and gate or trigger it from one state to the other with germanium diodes. The circuit in Fig. 8A illustrates how this can be done. It is possible to do this for the same reason that it is possible to use a pair of diodes for gate expansion, in which the two diodes on each side of the setup operate as positive-logic OR gates.

In the circuit of Fig. 7B, turn-on of a transistor is accomplished by pulling its collector down to near ground potential. It then turns on as a result of cross-coupling. In the circuit of Fig. 8A, the same result is obtained by driving the base positive with a logic 1 input. Minimum input logic level is about 50 percent higher than that required by the circuit in Fig. 7B, however.

A power-gated or buffered-input latch circuit is shown in Fig. 8B. A virtue of this circuit is that, with light loading, it will trigger reliably from one state to the other with an input current as low as a few microamperes. For a minimum-load setup, input resistors *R* can have a value as high as 500,000 ohms. It is important to note, however, that input logic level must be about 3 volts. Input current is exchanged for input voltage in this setup. The "high-step" input can help to improve noise immunity.

You can assemble a power-gated latch using a pair of inverters in a hex-inverter integrated circuit, or you can breadboard the whole circuit with four transistors as shown in the schematic diagram. You should use this circuit whenever you have a sufficient input-logic voltage level but inadequate input-logic current to operate a more common latch. *Do not attempt to get around the higher input logic level requirement by using a germanium transistor for triggering.* Leakage current through a germanium transistor is too great for this application.

The fan-in of the circuit if Fig. 8B is so low that, when used in the majority of digital

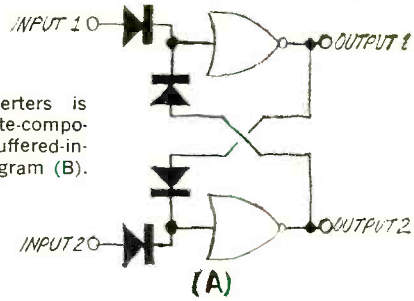
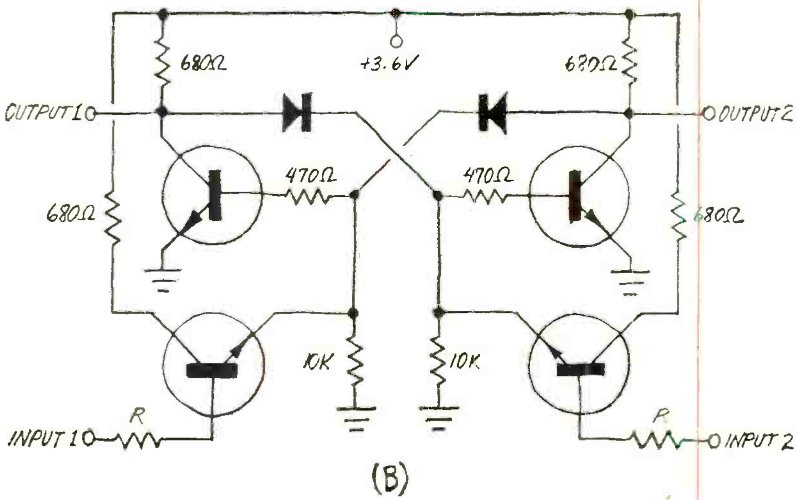


Fig. 8. Practical latch using inverters is illustrated in diagram (A); discrete-component circuit for power-gated, or buffered-input, latch is shown in schematic diagram (B).



logic layouts, it can be considered as practically an open circuit. It is especially useful as an exceptionally low-power input start/stop switch in counter and time-lapse applications.

An element which can supply the OR logic function and the AND logic function of two inputs simultaneously is of considerable value in digital circuitry. For one thing, with only slight modification, it forms the foundation for an EXCLUSIVE OR, or HALF-ADDER, element.

In the simultaneous AND/OR gate of Fig. 9, five diodes and four one-input gates perform all of the required logic functions. At the output of the two input inverters, one pair of the diodes provides the AND function, while the other pair, together with the 1500-ohm resistor, provides the OR function. A logic 1 is obtained at the OR output when a logic 1 is applied to input 1, input 2, or both inputs simultaneously. A logic 1 is obtained at the AND output only when a logic 1 is applied to *both* inputs simultaneously.

A state table for the circuit is also provided in Fig. 9. This state table lists all possible inputs to a digital logic element or device and the outputs which result from these inputs.

A half-adder or EXCLUSIVE OR Logic circuit is shown in Fig. 10. The circuit is ob-

INPUT 1	INPUT 2	OR OUTPUT	AND OUTPUT
0	0	0	0
1	0	1	0
0	1	1	0
1	1	1	1

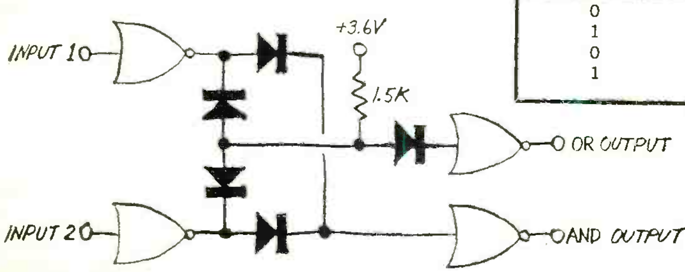


Fig. 9. Simultaneous AND/OR gate at left employs diodes and simple inverters. All possible inputs and their outputs are listed in truth table (above).

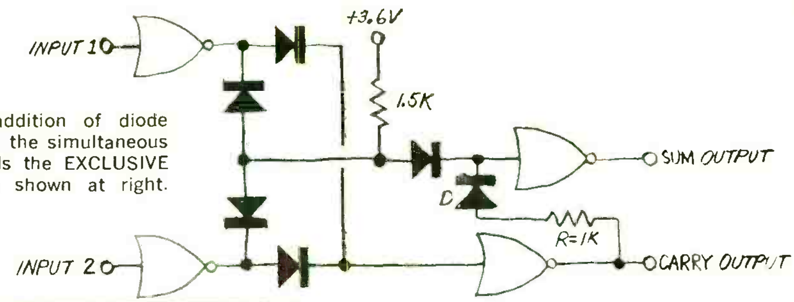


Fig. 10. Simple addition of diode D and resistor R to the simultaneous AND/OR gate yields the EXCLUSIVE OR circuit that is shown at right.

INPUT 1	INPUT 2	SUM OUTPUT	CARRY OUTPUT
0	0	0	0
1	0	1	0
0	1	1	0
1	1	0	1

tained by adding resistor *R* and diode *D* to the OR circuit of Fig. 9. (In some cases the diode may be omitted.)

In the circuit in Fig. 10, the EXCLUSIVE OR output is the SUM output, and the AND output is the CARRY. As shown by the state table in Fig. 10, the circuit provides a logic 1 at the SUM output when a logic 1 is supplied to either—but not both simultaneously—input. When a logic 1 is supplied to input 1 and input 2 simultaneously, the output is a logic 0, as it is when both inputs are logic 0. The outputs of the circuit demonstrate the fact that a logic 1 added to a logic 0, or vice versa, produces a sum of 1 and a carry of 0. A logic 1 added to a logic 1 produces a sum of 0 and a carry of 1.

A half-adder is required to sum only two logic inputs, whereas a full-adder must sum two inputs and a carry, for a total of three logic inputs. (A full-adder consists of two half-adders, plus some additional circuitry. Details of this circuit would simply digress from the subject of this article. Also, a full-adder would be impractical to breadboard in any event.)

Now, if we label input 1 with an A and input 2 with a B, then in a half-adder/subtracter in which B is subtracted from A, the following happens: First, the SUM output is identical with the DIFFERENCE output, such that the SUM or DIFFERENCE output supplies the EXCLUSIVE A OR B function. Next, the CARRY output supplies the A AND B function. And, finally, the BORROW output supplies the B AND A-COMPLEMENT function.

The circuit of a half-adder/subtracter, which can be readily breadboarded, is given in Fig. 11. It consists of five diodes, four inverters, and a dual two-input gate (or the equivalent in discrete form). This particular setup also supplies the complement of the SUM or DIFFERENCE output.

As you can see from the preceding, there is little need—or reason—for you to make a large financial investment in digital IC's if you want to experiment with and design logic elements and systems. Discrete components, and maybe a few commonly used gate IC's, will suffice for your breadboarding arrangements. You can select your IC's from the knowledge you gain through experimenting with discrete component elements. This is really the best and safest route to go when experimenting with integrated circuit digital logic techniques. —30—

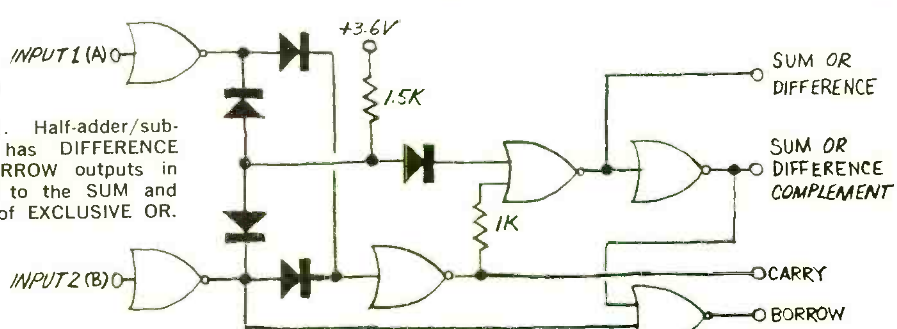


Fig. 11. Half-adder/subtracter has DIFFERENCE and BORROW outputs in addition to the SUM and CARRY of EXCLUSIVE OR.

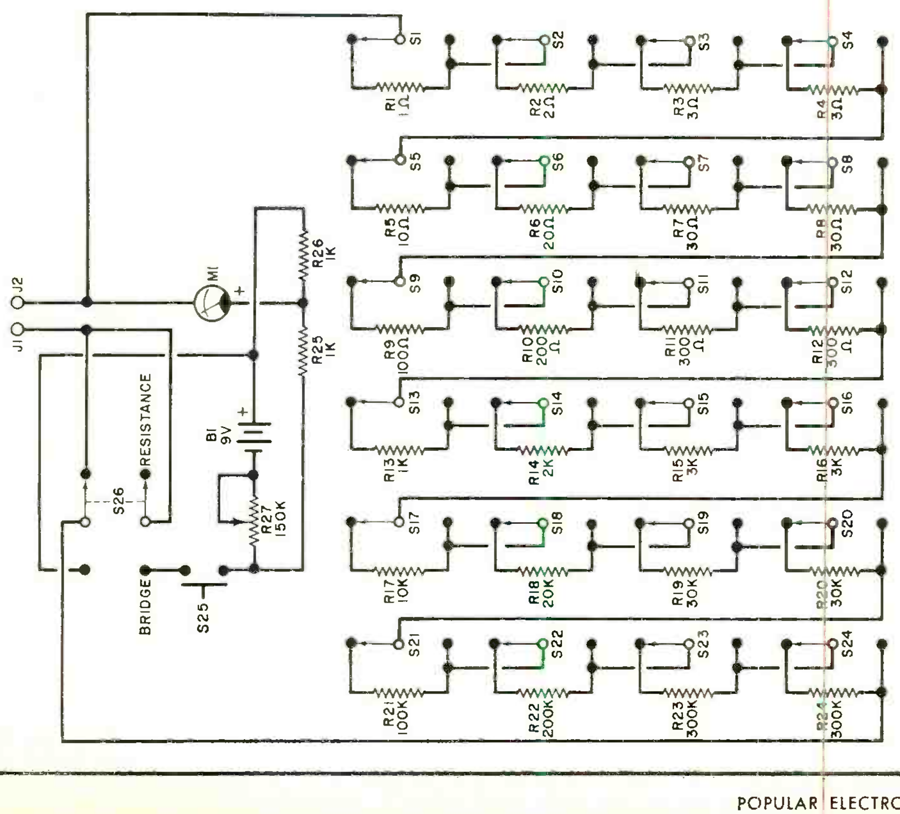
until the meter reads zero and reading the resistance of R_A.

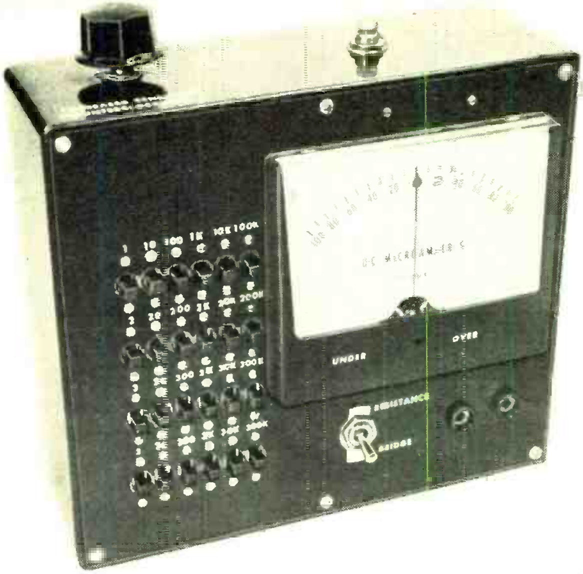
As shown in Fig. 2B, potentiometer *R27* controls the voltage applied to the bridge and provides a means of increasing or decreasing the sensitivity of the meter. The direction of meter movement is determined by the respective polarities of the meter and the battery. When the instrument is complete, attach a known resistance to terminals *J1* and *J2* and determine the direction of deflection caused by too much or too little resistance. It is customary to make the left side of zero "too little" (or "under") and the right side "too much" (or "over"). Mark the meter to indicate which side is which. The scale itself does not actually have to be marked except for an indication at zero.

PARTS LIST

B1—*9-volt battery*
J1,J2—*Five-way binding post or banana jack*
M1—*100-0-100 microampere panel meter*
R1—*1-ohm*
R2—*2-ohm*
R3,R4—*3-ohm*
R5—*10-ohm*
R6—*20-ohm*
R7,R8—*30-ohm*
R9—*100-ohm*
R10—*200-ohm*
R11,R12—*300-ohm*
R13,R25,R26—*1000-ohm*
R14—*2000-ohm*
R15,R16—*3000-ohm*
R17—*10,000-ohm*
R18—*20,000-ohm*
R19,R20—*30,000-ohm*
R21—*100,000-ohm*
R22—*200,000-ohm*
R23,R24—*300,000-ohm*
(R1 through R26: *All resistors ½-watt 1% tolerance*)
R27—*150,000-ohm potentiometer (preferably 10 turns)*
S25—*Spst normally open pushbutton switch*
S1-S24—*Spdt slide or toggle switch*
S26—*Dpdt slide or toggle switch*
Misc.—*Battery clip, alligator clip leads with banana plugs (2), perf board, knob, suitable cabinet with cover, wire, solder, etc.*

Fig. 1. Only 24 resistors are needed to make 999,999 combinations for substitution or for creating one arm of the Wheatstone bridge.





Any size zero-center microammeter may be used and the meter scale may be left "as is", or marked as "over" and "under" on the right and left sides, respectively. The meter scale divisions are not used.

Construction. The prototype was assembled in a large plastic case as shown in the photos. With the 24 switches mounted on the front panel, the precision resistors are connected directly to the switch terminals. In the prototype, the sensitivity control *R27* and the bridge power switch *S25* were mounted on the top of the cabinet with all other controls on the front. The battery is clip-

(Continued on page 99)

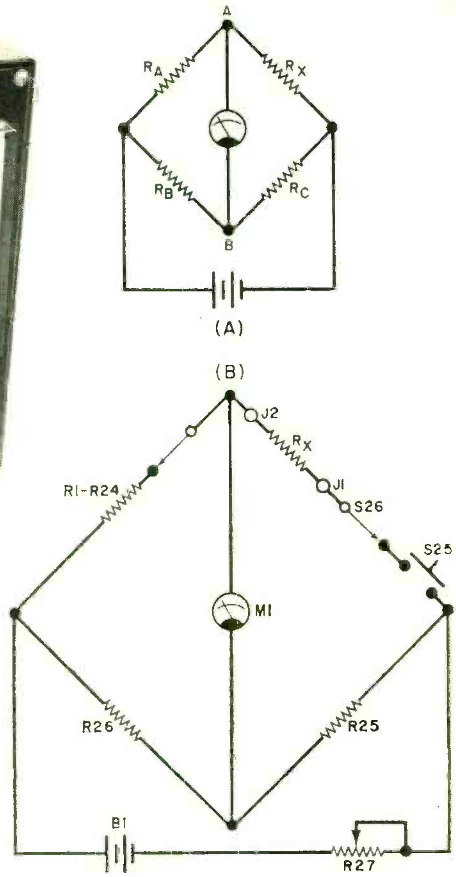
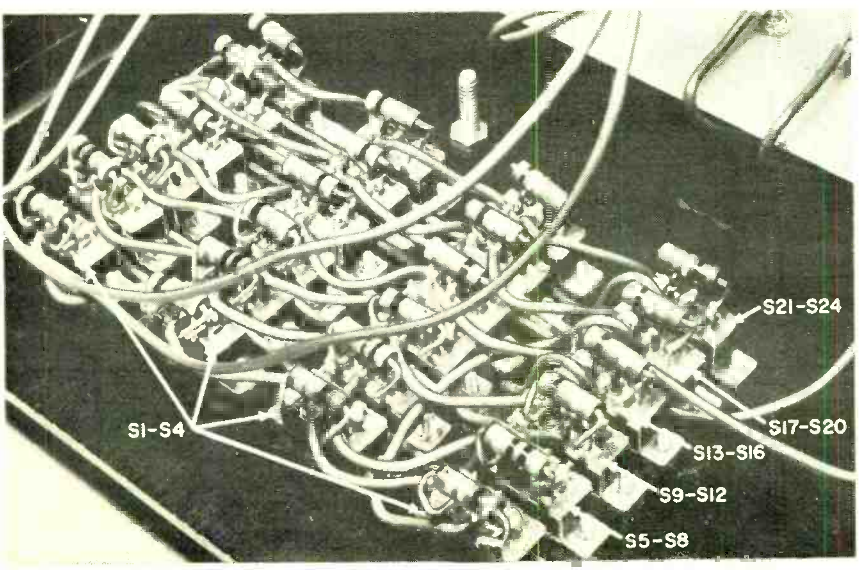
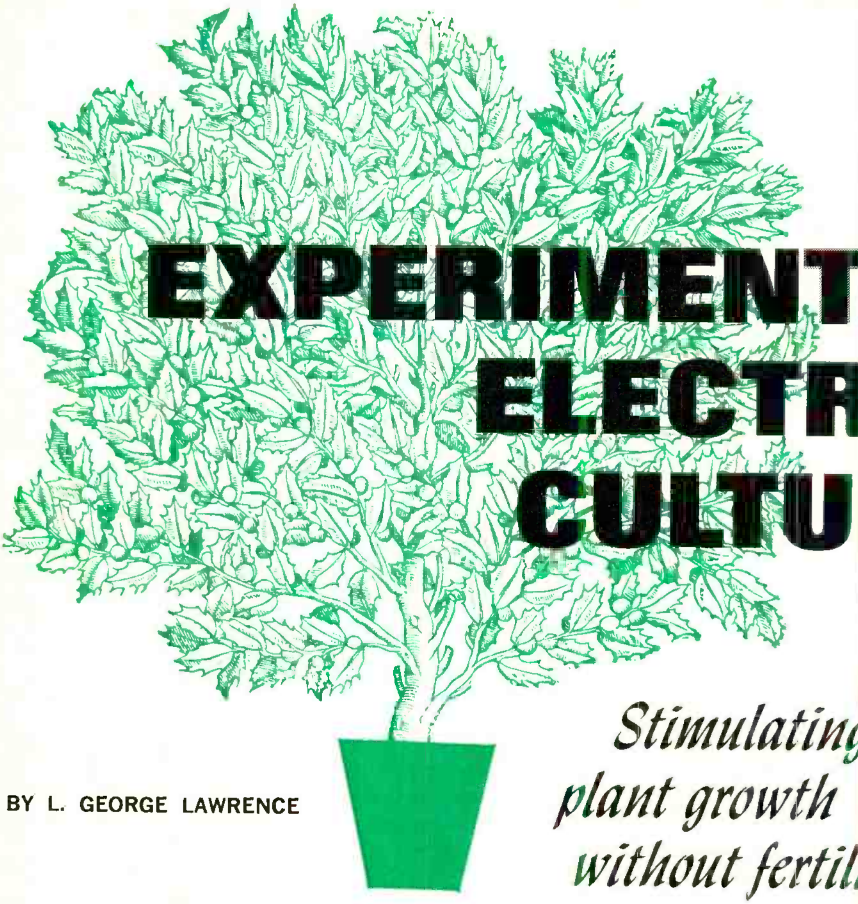


Fig. 2. The classical Wheatstone bridge is illustrated at A, while B shows how it is created in the bridge-substitution box project.



The bulk of the work is in cutting the holes to mount the 24 switches in the selector circuit. Be careful when drilling plastic as it shatters very easily. If there is any doubt, use a metal cover for the plastic container.



EXPERIMENTAL ELECTRO-CULTURE

Stimulating plant growth without fertilizers

BY L. GEORGE LAWRENCE

This is an experimental arrangement developed by the author to test certain theories relative to stimulating plant growth in a very high voltage electrostatic field. Details on the equipment built for the experiment are detailed and some of the background on the "why" of electro-culture is discussed.

HANGING your pet geranium upside down in the cellar all winter isn't necessarily all it takes to grow a beautiful plant next spring. Of course, amateur horticulturists—as well as professionals—have any number of theories about how you can automatically have a green thumb; but several historical and many more recent experiments have shown that successful gardening isn't just a matter of fertilizing, watering, and tender loving care.

Indeed, only a handful of people realize the role that natural electricity plays in the development of plant life. Yet, in 1902, physics professor S. Lemstroem, after a trip to the northern polar regions, decided that the rapid growth of vegetation during the short arctic summer was due to the unique electrical conditions of the atmosphere in those latitudes. Back in his laboratory, Professor Lemstroem reproduced the assumed arctic conditions by increasing the atmospheric current (which normally flows from the air to the plant) by placing a wire with a high static charge on it (generated by a Wimshurst machine) over a plant. An increase in plant yield was noticed.

Study of electro-culture (as the science is called) began with basic experiments by a Dr. Mambray in England in 1746. Later, in 1879, a French scientist, L. Grandeau, saw dramatic possibilities in the field which he described in a paper "Influence de l'Electricite Atmospherique sur la Nutrition des Vegetaux." But the real break came in 1902 with the Lemstroem experiments.

In more recent times, other experimenters extended the work to treatment of viable seeds using radio-frequency and ultrasonic methods. The r-f techniques involved frequencies above 30 MHz applied for a few seconds to seed bags placed into r-f tank circuits. Ultrasonic schemes involved the brief dipping of bags into baths agitated at frequencies up to 1 MHz. Plants grown from seeds treated in this way had yield profiles ranging from fair to excellent.

Fertilizers Spoil Picture. It was the invention and use of cheap chemical fertilizers that effectively suppressed electro-cultural engineering. Today, however, we are in the position where nitrate pollution by these very fertilizers threatens not only our water supply but the entire ecological panorama as well. Thus it would appear that the revival of electro-culture is not only desirable but imminently necessary.

Experimenting with electro-culture is hardly the same as building a stereo amplifier or a digital voltmeter. For one thing, high, static voltages are involved and a good degree of professionalism is required to obtain good results. (Keep in mind that we are concerned with living plants, which have their own peculiarities and may not *always* respond as expected—only large-scale trends are important.)

Typical electro-culture systems frequently operate unattended for long periods of time in an open-air environment. This requires heavy-duty construction in both the electrical and mechanical aspects of the equipment.

MORE INFORMATION?

See:

"Electronics and the Living Plant," L. G. Lawrence, *Electronics World*, October 1969.

Plant Physiology, E. C. Miller, McGraw-Hill Book Co., New York, 1938.

However, expenditures can be kept low by using surplus-type materials. In the case of an experimental electro-culture system using high-voltage discharge, the cost of a typical exciter unit can be below $35.00.

Basic System. A schematic of a Lemstroem type of electro-culture system is shown in Fig. 1. Here, the positive terminal of the high-voltage power supply is connected to the overhead wire, with current return through a ground path. Potentials are as high as 20,000 volts—up to 60,000 volts for short periods of time. While natural atmospheric currents range between 10^{-16} and 10^{-15} amperes, the excitation provided by the high-voltage wire provides currents around 10^{-12} or 10^{-11} A, as measured by a sensitive electrometer. In open-air experimental fields, the height of the overhead discharge wires with respect to ground may be from 3 to 10 feet. The height above ground naturally affects the amount of atmospheric current. Remember that the high voltage essentially serves as a "current carrier"—appropriate current values cannot be generated under other than high-tension conditions.

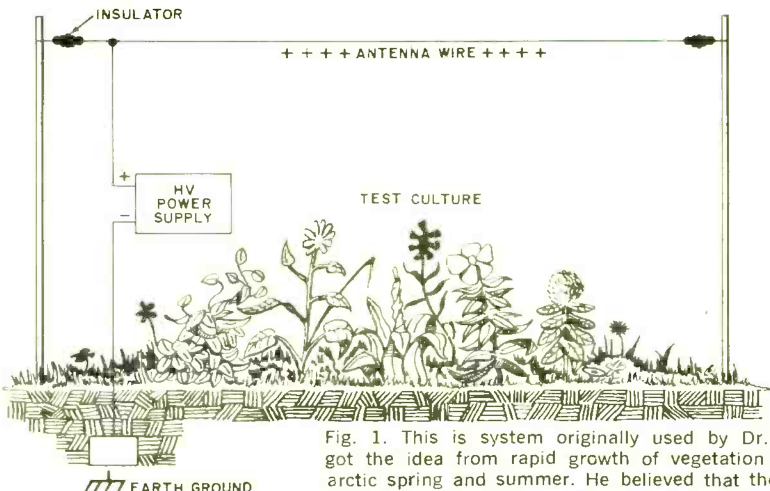


Fig. 1. This is system originally used by Dr. Lemstroem who got the idea from rapid growth of vegetation during the short arctic spring and summer. He believed that the natural high atmospheric current was responsible for extremely rapid growth.

Fig. 2. Provision must be made to prevent animals, children, or strangers from touching the high-voltage lead. A simple wooden barrier is sufficient.

High-voltage electro-culture systems may take the form shown in Fig. 2. The apparatus was designed to investigate the susceptibility of many different plants to stimulation. The equipment generates ozone (O_3) and must be used in well-ventilated areas only.

An electrical schematic of this system is shown in Fig. 3. Transformer *T1* has an output of 3000 volts rms. After rectification, the effective dc is approximately 4200 volts. A dropping resistor may be necessary on the filament winding to obtain the correct voltage for the rectifier. If leakage current in the reverse mode can be tolerated, a high-voltage rectifier diode may be used instead of the tube and filament winding.

The 3000 volts dc generated is highly dangerous to touch.

Resistor *R1* (made up of several resistors in series) serves as a current limiter and can be anywhere from 5 to 20 megohms, the latter value limiting the current to 210 μA in the event of an accidental short circuit. Resistor *R1* may be in series with either the positive or negative output terminal.

Resistor *R2* is connected to two pieces of high-voltage cable with the connections and resistor thoroughly wrapped with high-voltage insulation so that the resistor is actually imbedded in the cable. Put insulated alligator clips on each end of the cable. This resistor forms a safety discharge shunt and *must* be

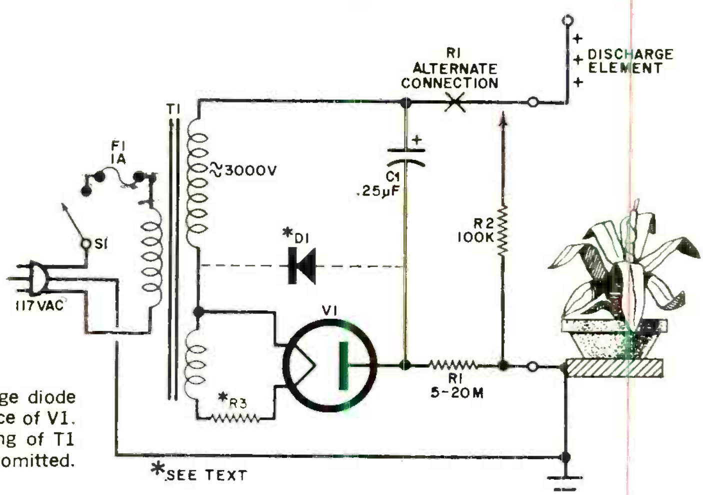
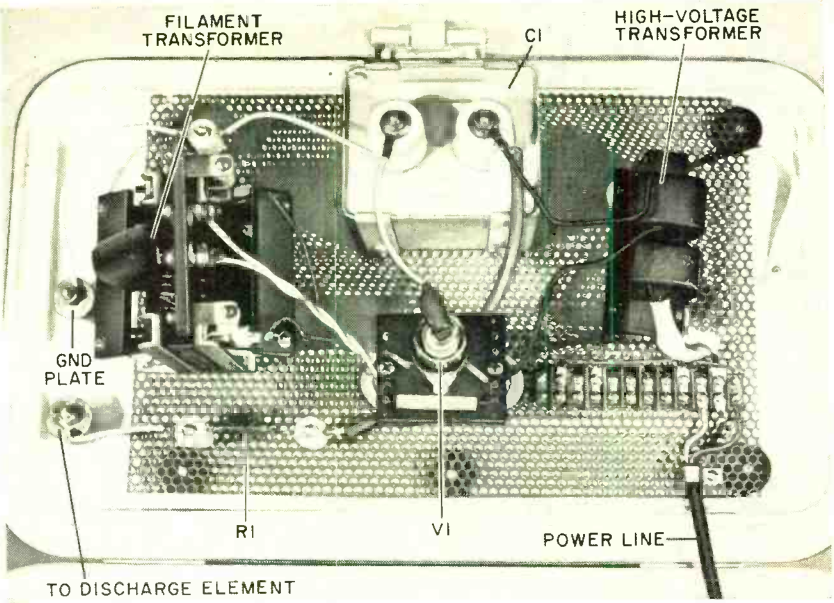


Fig. 3. A high-voltage diode may be used in place of V1. The filament winding of T1 and R3 can then be omitted.

PARTS LIST

C1—0.25-μF, 7500-volt capacitor
F1—1-ampere fuse with holder
R1—5-to-20-megohm resistor (see text, ½-watt each)
R2—100,000-ohm, 2-watt resistor
R3—See text
S1—Spst slide or toggle switch
T1—Oscilloscope transformer; secondaries: 3000 volts and 6.3 volts
V1—Half-wave, high-voltage rectifier tube
Note—Alternate rectifier diode D1 (IR 67 D-050H55FNN) can be used as shown by dotted line. See text.
Misc.—Large plastic container, 3-lead power line, mounting plate, insulators, high-voltage cable (10-kV test), hookup wire, hardware, ground plate for pot.



Because the relatively weak plastic chest cover will not support much weight, a perforated metal base plate is used to mount the heavy components. Feedthroughs are used to couple to the "antenna" and the main ground plane that supports the flower pot.

connected across the output terminals when the apparatus is shut off to discharge capacitor *C1* and the antenna structure ("discharge element" in Fig. 3).

The power supply's physical layout is shown in Fig. 4. For safety's sake and good appearance, the entire power unit is mounted on the lid of a plastic camping chest. Ceramic insulators are fastened to the lid to provide connections for the discharge element and ground wires. A simple ground electrode is inserted into the moist dirt (earth mixed with moss is good) in the pot and the pot sits in a metallic basket which is connected to the negative terminal of the supply. The antenna or discharge element is connected to the positive terminal and consists of a simple metal rod.

The 117-volt line cord is a grounded 3-wire type, with the green (ground) wire connected to the perforated-steel mounting plate on which the plant basket sits. The high-voltage transformer is mounted on insulators and the rectifier tube socket is mounted on insulators on a bakelite terminal board. The string of resistors comprising *R1* is fastened to standoff insulators of the ceramic type. In the model shown in Fig. 4, a separate transformer was used for the tube filament supply with dropping resistor *R3* mounted on the bakelite terminal board. The entire high-voltage section is wired with high-voltage cable tested to 10,000 volts dc.

R-F High-Voltage Supply. A schematic for a radio-frequency high-voltage unit is shown in Fig. 5. It is an inexpensive and slightly less dangerous alternate to the supply described above.

Effective dc output of this supply is 5000 volts at 200 microamperes maximum. Thus, should the supply's output electrodes be touched accidentally, an unpleasant, but nonlethal, shock will be experienced.

Electronically, the supply is comprised of a straightforward feedback oscillator. Optimum oscillator frequency is approximately 225 kHz. Tube *V2* is a half-wave rectifier. The supply may be constructed on a simple chassis and installed in a manner similar to the one shown in Fig. 2.

Note, however, that the transformer specified for *T1* does not have a filament winding for the rectifier. A filament loop may be added simply by placing one turn of No. 20 insulated high-voltage wire around *T1*'s ceramic base, being careful to maintain spacing from the tuned r-f circuit. (Follow the instructions packaged with the transformer.) A VTVM or similar high-impedance meter my be used to measure output voltages without excessive

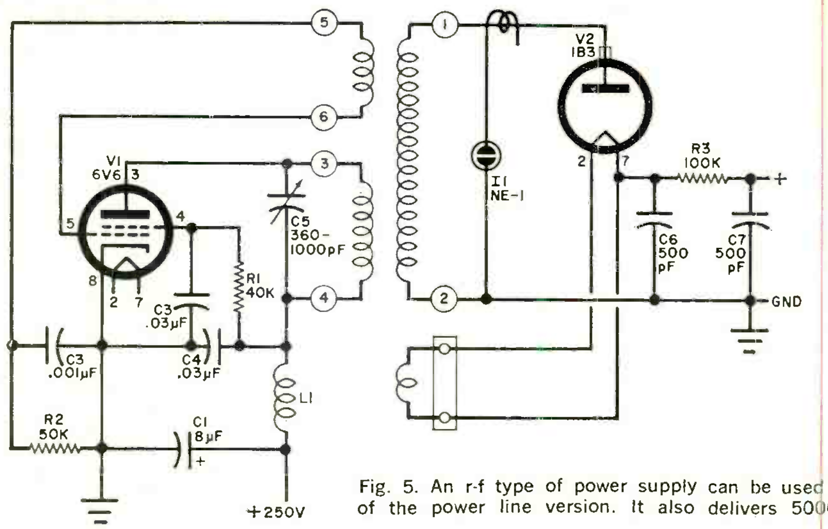


Fig. 5. An r-f type of power supply can be used instead of the power line version. It also delivers 5000 volts.

PARTS LIST

C1—8-μF. 350-volt electrolytic capacitor
C2,C4—0.03-μF, 600-volt capacitor
C3—0.001-μF, 600-volt capacitor
C5—360-1000-pF tuning capacitor (J.W. Miller 160-A or similar)
C6,C7—500-pF, 10-kV capacitors (TV type)
I1—NE-1 neon lamp
L1—2.5-mH r-f choke (J.W. Miller 4537 or similar)
R1—40,000-ohm, 1-watt resistor
R2—50.000-ohm, 1-watt resistor
R3—100-000-ohm, 1-watt resistor
T1—High-voltage, r-f transformer (J.W. Miller 4525 or similar)
V1—6V6 tube
V2—1B3 tube
Misc.—Suitable high-voltage and filament supply, insulated chassis, tube sockets, high-voltage wire for 1B3 filament winding (see text), cap for 1B3.

loading. After wiring is complete, remove rectifier tube *V2* and adjust the oscillator for maximum output power by tuning capacitor *C5* with an insulated alignment tool. Place a "gimmick" or single-turn coupling loop with a neon lamp on the output of *T1* as shown in Fig. 5 and tune the circuit until the lamp attains maximum brilliance. Remove the neon lamp and gimmick after tuning is complete. In operation, it is proper for the filament of the 1B3-GT to glow a dull red.

Safety Precautions. Due to the inherent shock hazards involved in either of the systems described here, they should be operated behind a simple wooden barrier marked to keep away "unauthorized personnel." The experiment may then be operated near a window or other well-lit area indoors.

The equipment may also be operated outdoors, preferably in a fenced-in private garden, provided it is protected from rain and moisture and the proper precautionary measures are employed. With component values shown, an "antenna" height of three feet is suggested—depending on local wind conditions and ambient aerobic moisture content.

When it is necessary to work on a plant or water it, turn off the power and connect safety shunt *R2* across the high-voltage terminals. When watering, avoid wetting the electronic equipment and the high-voltage discharge element. When you are through working on the plant, remove the safety shunt, get out of the way, and turn the power back on.

Always keep safety uppermost in your mind. Physically protect the electro-culture experiment from strangers, children and animals.

What Can You Expect? According to data advanced by Dr. K. Stern and others, a true increase in yield of 45 percent for a well-cultivated field can be expected. Yield differences are determined by comparing results against non-treated control cultures of the same type. Some plants give very low yield

(Continued on page 96)

Sixth in a Monthly Series by J. Gordon Holt

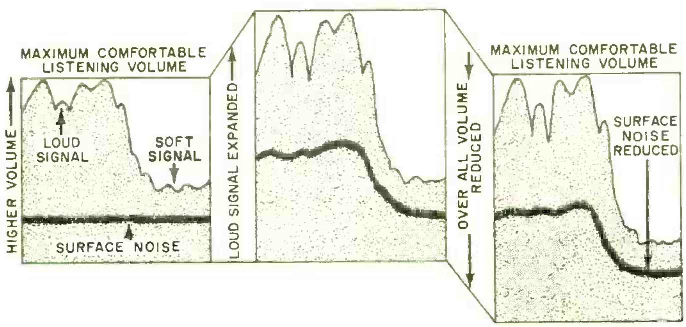
ALTHOUGH I haven't really tried, I suspect it would be quite difficult to find an audiophile who has never heard of *The Dolby*. The Dolby noise-reduction system has been discussed in record reviews, learned audio journals, and the hobbyist publications that serve as the "popular press" in audio circles, to the extent that it would seem safe to assume that everybody who cares knows what the Dolby is, how it works, and why. But, judging by conversations I have had with some audiophiles and, on occasion, with supposedly knowledgeable professionals, this is *not* a safe assumption. There is still much misunderstanding about the Dolby, and the situation was not improved by the appearance of a Dolby variant known as the *B Dolby*, to distinguish it from the original Model A301 or *A Dolby* version.

At first, it struck me as odd that the people who least understood the Dolby were often those with the most experience in audio. Finally, it occurred to me that they had encountered noise-reduction systems before, they understood how those worked, and they assumed that the Dolby was another variation that just happened to work a bit better. Well, it isn't. It's an entirely new approach to the problem of background noise, and its success stems from the approach rather than from the refinement of an old idea.

Early noise-suppressor designs, aimed at the irksome hiss from 78-rpm discs, were based on the premise that, since surface noise originates with the recording itself and thus doesn't show up until the playback process, any noise-reduction gadget had to be in the playback system. The basic problem was that, once the audio signal was inscribed in the disc grooves, there was no way of separating the signal modulations from the groove-surface irregularities that cause hiss. Since hiss is primarily high-frequency energy, the obvious way of reducing it was by filtering out the high-end response of the playback system. The hooker, of course, was that this also took out the high end of the program material. The question, then, was how to filter the treble from the surface noise without filtering the treble from the program?

Researchers and record listeners alike had observed that surface noise was most conspicuous during quiet passages, and tended to be covered up or "masked" by loud program material. This suggested the possibility of a "dynamic noise suppressor" that would reduce noise only when the program content was quiet or absent.

Two approaches were tried. One system used the volume of the program material to control the amount of treble filtering applied to the signal. When little or no signal was coming through, the treble "gate" would close, filtering out the surface noise. When the signal got louder, it caused the automatic control circuit to open the treble gate until,



These three charts show how the volume expansion system "seemed" to reduce surface noise in 78-rpm discs. It worked to an extent but the overall effect was not sufficient to warrant its acceptance.

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Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for Mr. Chet Martin, who has faithfully seen to it that my supervisor knows I'm studying. I think Mr. Martin's monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. Mr. Martin has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructer. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience.

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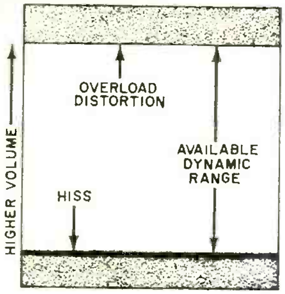


The available dynamic range of any recording medium lies between overload distortion point and gackgorund noise level.

at full volume, it was wide open for maximum high-end range.

The other approach used the program's volume to control the volume of the entire sound, in order to provide an *expansion* of dynamic range, making loud passages louder still. This gave satisfyingly full crescendos, and since the *average* listening volume had to be reduced to avoid crescendo overloads, there was also an apparent reduction in surface noise during the quieter, un-expanded passages. This approach also, incidentally, restored to the music some of the original dynamic range which had had to be compressed to conform to the limitations of the 78-rpm medium.

Both systems worked, in that they did a pretty nice job of reducing record scratch, but they were far from *The Ultimate Answer*. In order for the treble gate or the expansion control to pass a sudden, loud, signal impulse, it had to be able to respond very rapidly, and this meant that it was also likely to respond to disc surface ticks and pops. And since the variable-gain circuits that caused the gating or expansion were inherently nonlinear, they introduced more distortion than a lot of listeners were willing to accept. There were other problems, too. The control and gating circuits often tended to over-react or to function with instability, causing an accompaniment of thumping or "breathing" noises that some people found more annoying than the record scratch they replaced. So, noise suppressors came, but none endured.

Enter the Dolby. Then along came a young electrical engineer, Ray Dolby, who hadn't the slightest interest in record surface noise (78's were 20 years in the past), but had worked with Ampex Corporation long enough to learn what a problem *tape* noise could be in multiple-step duplicating—the normal course of commercial record production. His answer was absurdly simple in principle. Instead of trying to reduce playback with minimal effect on the program, he let the program be drastically affected by the noise reduction, and compensated for the effects during the recording process.

This is easier to do than it sounds. If the signal can be used to expand its own dynamic range or attenuate its own high end in playback, it can just as easily be made to do the opposite thing during the recording process. And if exactly the same control circuitry is used, first in one direction and then in reverse, the action of the system during playback can be made a virtual "mirror image" of its action during recording, so that the signal is restored to its original state. The nice thing about this mirror-image processing is that, even if the control circuits in the record phase are nonlinear or somewhat slow to react or prone to produce overshoot, the playback control circuits will "malfunction" in exactly the same manner but in reverse, and will cancel out the problems.

The noise-reduction action of the Dolby is easy to visualize if we consider the available dynamic range of a tape. Overload distortion sets the upper limit of recorded signal level, while the lower limit is set by the tape's inherent background noise. So, how can we squeeze a signal with 60 dB of dynamic range into say a 50-dB space between the tape's overload point and its hiss level? We can do it by compressing the 60-dB volume range of the signal down to 50 dB before it goes onto the tape. In playback, the softest signal will still be above the hiss level, but we're now 10 dB shy of the original signal's dynamic range. So, we use the same compression circuits in reverse during playback, to stretch the signal back to its original 60 dB, and as the quiet passages are made 10 dB quieter, so is the accompanying tape hiss.

There is another way in which the Dolby differs from previous noise suppressors: It will not help program material that is noisy to begin with, and a moment's thought should make it clear why. If the noise is mixed in with the program, Dolby record compression will affect both the noise and the signal, and Dolby playback stretching will restore both to their original levels, without changing their relationship. If we use the playback stretcher only, without first compressing the material, surface noise will be reduced along with the quieter parts of the program. This might not sound too bad were the actual Dolby nothing more than a volume compression and expansion system, but it's more.

Not Quite That Simple. The Dolby A301 device that finally became the workhorse of the recording industry is one very complex gadget. Its compression and expansion act only on low-volume signals, leaving loud signals unchanged. It is much more sophisticated than previous expander-compressor designs in that it takes into account the fact that noise is most effectively masked by signals of *similar* frequency. Thus, instead of a simple broadband volume expander, it divides the audio spectrum into four separately controlled bands. The range below 80 Hz is controlled to reduce rumble (which can arise from tape coating irregularities or recorder imperfections), the 80- to 3,000-Hz range is controlled to reduce broadband noises such as stereo separation leakage and print-through, and the ranges above 3 kHz to 9 kHz and on out are individually controlled to reduce hiss.

The resulting device lowers recording-induced noises by as much as 10 dB at frequencies up to 5 kHz and by as much as 15 dB at 15 kHz—without audibly affecting the desired signal in any way. The A301 costs $1,495 for two channels of record or playback processing. If you want to record-process and playback-process two channels simultaneously, so you can monitor from the output of a tape while it is being Dolby-recorded, you need two A301's. Understandably, the average audiophile's only contact with A301's has been through the quieter recordings he's bought that were made using this system.

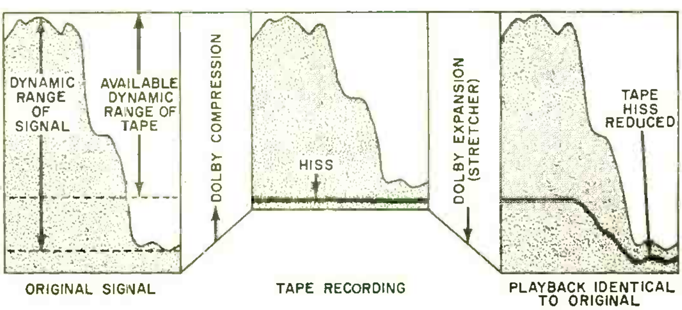
Actually, vinyl discs had never been all that noisy to begin with. The *real* noise source in the home has been commercially pre-recorded tapes (especially cassettes), and since most of the hiss from these originates in the final mass-duplicating process, it was academic to the home listener whether the previous master-tape copies had been Dolbyized or not. What was needed was a Dolby in the home, but not at almost $1,500. The result was the B Dolby.

Since the noise problem in the home was primarily tape hiss, the B Dolby was made to concentrate on that exclusively. Instead of four controlled bands, the B design operates only through the upper-frequency range above 1,200 or 3,000 Hz. The greatly simplified circuitry, plus the absence of professional "frills" allowed the home-type B model to be produced at prices an audiophile could afford. Two manufacturers were quick to get their versions of the B on the market. KLH was first with its Model Forty tape recorder that had a built-in Dolby B, an excellent electronics section, and so many early-production mechanical problems that the unit earned an undeserved blacklisting by the buying public before it had even proven itself. (I understand the Forty-One works fine.) Advent Corporation followed KLH with its Model 100, which is a self-contained component-type B Dolby for use with any tape recorder. It is an eminently popular design for the perfectionist who will pay $250 to gain 10 dB of signal-to-noise ratio.

Not For Cassettes? At that time, nobody entertained seriously the idea of using a Dolby B with cassettes. Cassettes were so bad in so many ways that their execrable hiss was just considered further proof of their hopelessness. But as cassettes improved in other respects, leaving hiss as their main drawback, the Dolbyized cassette no longer seemed an inane idea. At least it didn't to the Fisher, Harman-Kardon and Advent companies, all of which brought out in late 1970 cassette recorders with built-in B's. In each case, the B does a truly remarkable job of eradicating hiss, and this plus the new DuPont "Carolyn" cassette tapes promise to make the cassette a quite respectable medium for everyone but the real audio perfectionist.

The Dolbyized cassette is just beginning to come into its own. Before the Dolby, cassettes that you recorded yourself (on low-noise tape) were capable of around 45 dB of s/n ratio, which isn't all that bad. By comparison, a good 4-track open-reel recorder may measure (without weighting) around 55 dB. The typical pre-recorded cassette, on the other hand, has less than 40 dB of s/n, which is not good. Any attempt to reproduce these via the B Dolby playback stretcher, without preliminary compression, causes excessive stretching (downwards) of the high frequencies and makes the sound

(*Continued on page* 97)



The Dolby system reduces hiss by a compression and expansion process on low-volume signals; loud signals remain unchanged.

THE PRODUCT GALLERY

Sixth in a Monthly Series by "The Reviewer"

ELECTRONICS experimenters and electronics development or repair technicians have many things in common. Particularly pertinent to this column is the realization by experimenters and technicians alike that the old reliable pieces of test equipment are rapidly becoming antiquated and just can't do a proper job with 1971 circuits.

To lay out, design or repair semi-conductor circuits involving the use of IC's and discrete transistors requires measuring and test instruments of greater sensitivity, bandwidth, and flexibility than those old faithfuls used in the day of the vacuum tube. Even most VOM's or VTVM's just can't cut the mustard when it comes to low voltage measurements. Except for a few isolated instances, medium-priced oscilloscopes designed prior to 1969 shouldn't even be discussed. A scope having an ac range from 5 Hz to a couple of megahertz will not be able to display the high-speed waveforms racing through many digital circuits, color TV, etc. Even if you do find a scope that can display these waveforms, it is a hairy job just to keep the scope in synchronization unless it uses triggered sweep.

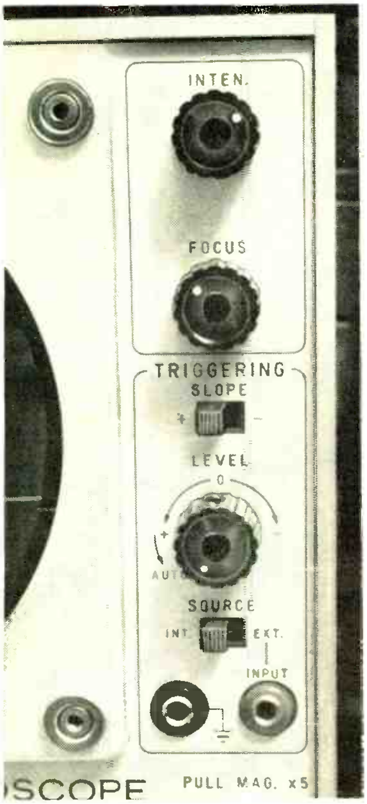
LEADER INSTRUMENTS LBO-501 OSCILLOSCOPE

For several years I have been using one of the more popular—and one of the first—triggered sweep oscilloscopes. It is, of course, built around vacuum tubes and has performed quite satisfactorily. When the Leader Instruments LBO-501 oscilloscope came to hand, I was really not prepared for this rather astonishing (less than $340) instrument. It is a Japanese import with solid-state circuits except in certain parts of the vertical amplifier and triggered-sweep generator. It is safe to say that the Leader LBO-501 scope is four or five different instruments in the same package. Obviously, you can display just about any waveform under investigation and you can make an extremely accurate measurement of signal amplitude. Frequency (or time) can be measured through the use of the switch-selected or variable time base (17 options). You can change the graticule and convert the LBO-501 to a vectorscope, and you can also use it for television servicing and repair with help from the factory-calibrated fixed frequency sweeps (vertical rate of 33.3 mS and horizontal rate of 127.0 μS).

Naturally, this scope has triggered sweep and once the test probe is connected, the display becomes impervious to any other signal coming in for the duration of that sweep period. After retrace, the sweep is again triggered and the cycle repeats. Because random triggering is eliminated, there is no trace jitter. Such a circuit lends itself to the use of a series of different sweep rates, and since they are all extremely linear, the scope's horizontal graticule can be calibrated in microseconds, milliseconds, or even seconds per scale division. This is how frequency is measured. Besides the sweep speeds that range from 1 μS to 0.2 second per horizontal division, a variable control is provided for in-between measurements. A ×5 magnifier switch permits the operator to expand the center of the sweep for close-in waveform examination. The horizontal can also be triggered from an external source and access has been provided to the horizontal amplifier input without the sweep. The bandwidth here is claimed by the manufacturer to be from 2 Hz to 200 kHz.

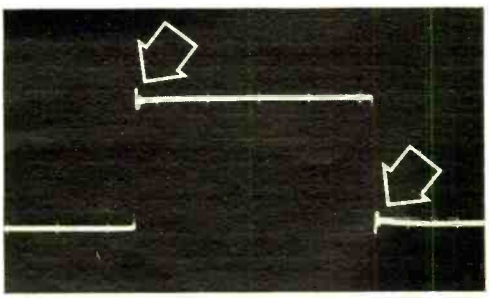
Performance Tests. The scope speeds of the LBO-501 were tested using the "Time Base Calibrator" construction project described in the January issue of this magazine (p 33). The accuracy of the sweeps was remarkable and this reviewer could not discern any deviation from the square wave pattern being produced versus the graticule calibration. Incidentally, the very high rate of triggered sweep showed up some

LEADER INSTRUMENTS LBO-501 OSCILLOSCOPE

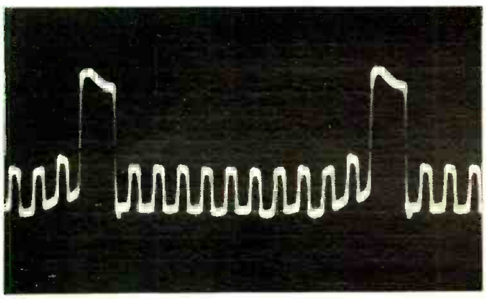


SWEEP TRIGGERING CONTROLS. Besides obvious usual focus and intensity controls, LBO-501 permits an option of internal or external triggering with positive or negative display of the triggered signal.

AMPLIFIER AND TIME BASE CONTROLS. Horizontal time base is switch selected in 1-2-5 sequence from 1 microsecond to 0.2 second per centimeter of display. Calibration jacks supply voltages to verify accuracy of vertical amplifier. We found fault with single full-on/full-off switching of graticule illumination from rear of scope. Supplied probe not used in this photo.



100,000-HERTZ SQUARE WAVE. To demonstrate versatility of the scope this photo was taken of a 100-kHz square wave which is just starting to show ringing and overshoot. The claimed rise time of the LBO-501 scope is 0.035 microsecond, which means a useful response to about 30 MHz.

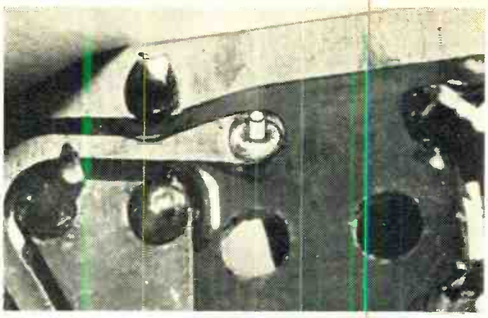


COLOR TV DISPLAY. The LBO-501 was used to check out the Heathkit GR-370 also mentioned this month. Display above shows the color bar signal at the chroma circuit board. Here the horizontal time base has been switched to the precalibrated 127 μs/cm for the TV horizontal circuit testing.

high-frequency ringing that just wasn't visible on our older oscilloscope. The vertical calibration of the LBO-501 was checked against the Heath EU-80-A voltage calibrator and also found to be right on the money. The LBO-501 has a built-in voltage calibrator with three banana jack outputs on the front panel providing 5.0, 0.5, and 0.05 P-P outputs. And internal calibration adjustment is available should the transistors in this circuit "age." Similar provisions are made for the timing switch circuits involving television vertical and horizontal sweep rates.

The LBO-501 is supplied with three different probe tips that screw into the probe handle. One is a sharp needle point, one is a bare hook for conventional test point checks, and a third is a thumb-operated locking hook with a 10:1 attenuator that presents a 10-megohm, 15-pF load to the circuit under test.

If you haven't guessed it by this time, your reviewer was impressed by not only the price, but the flexibility and versatility of the Leader LBO-501 scope. It will be interesting to see how this scope stands up under everyday use. Due to the extensive use of transistors the cabinet runs much cooler (no circulating fan required) and the unit itself is about half the weight of comparable products. About the only annoyance noted to date has been the graticule illumination which is unfortunately switch controlled from the backside of the instrument. Also the graticule illumination cannot be varied in intensity and if this reviewer keeps the scope around, he intends to add a potentiometer to vary the voltage fed those two pilot lights.



IT LOOKED SOLDERED. Only major headache in building the Heathkit GR-370 was our own failure to realize that one lead of an agc bypass capacitor had not been soldered. It is a common problem with small (green colored) Mylar capacitors that have been dipped in plastic. Some of the plastic gets on the wire leads and prohibits an electrical connection. This retouched photo shows how solder puddles around the wire lead, rather than adhering as shown in the other connections.

HEATHKIT GR-370 WRAP-UP

As reported here last month (p 86), the assembly process of the Heathkit solid-state color TV Model GR-370 took 34 hours—including time spent building the remote control GRA-70-6. The receiver produced a full raster at first turn-on and everything looked OK until the antenna was connected. Then the picture tore and the agc was ineffective. Resistance checks (see last month, p 88) indicated that the transistors and resistors were OK and that the problem was probably an open capacitor. As it turned out, this was true and the retouched photo shown here may give builders an idea of what to look for when soldering in the plastic-coated "green" Mylar capacitors.

The GR-370 has been operating for several weeks—as this is being written—and outside of normal minor "aging-in" adjustments, we are quite pleased with the performance. The "instant-on" (really delayed some seconds) turns out to be one of those things we wonder how we managed to get along without. Setting brightness, noise limiting, AFT, convergence, purity, etc. were all relatively easy and positive. The return of the tone control is a blessing in cutting down some of the Saturday morning cartoon violence.

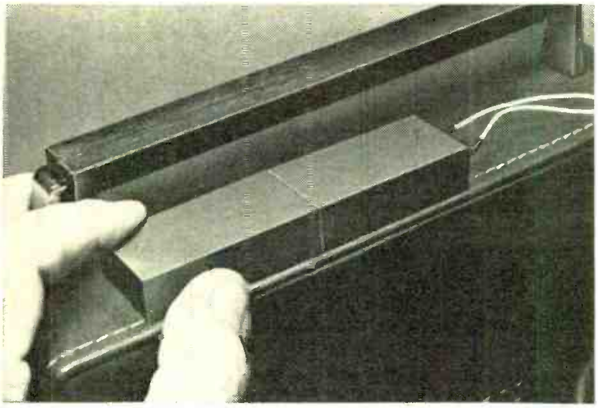
In general, the experimenter will find the GR-370 (or GR-270) a unique and challenging kit-building experience. If a vacuum-tube color TV has been assembled in the past, the new emphasis on accessibility and ease of servicing will be appreciated. And, if all the stories about the longevity of solid-state are true, the GR-370 will outlast all other receivers by a wide margin.

RUSSELL BCB ANTENNA BOOSTER

In case you didn't know it, there's something missing in just about every transistorized AM broadcast band receiver—antenna input terminals. About a decade ago, you couldn't buy a BCB portable radio without antenna input terminals. But, as manufacturers became more cost conscious and ferrite loopsticks more efficient, the antenna terminals were eliminated. It is quite likely that 25% of those listening to AM broadcasts have excessive background noise and weak signal reception.

The experimenter could open up just about any transistor AM portable and add a few turns and his own antenna terminal connections. A better way appears to be getting one of the Russell Products "Radio Antenna Booster" encapsulated loopstick and lay it on or attach it to his AM portable. The Russell Booster has its own antenna wire and ground lead (with alligator clip). The user simply clips the ground lead to any appropriate metallic ground and unrolls the 4' insulated antenna wire. Inductive coupling between the ferrite loopstick in the Russell Booster and the receiver loopstick adds up to 30 dB of signal on the AM broadcast band.

I almost wish that there was something tricky or startlingly unusual about this gadget, but it is just as the advertiser claims and really works. Your reviewer has used it in conjunction with the Radio Shack "AC-DC Long Range TRF" AM receiver as a red-hot DX'ing combination. Daytime reception of AM broadcasting signals 90-125 miles distant is no problem and at night the only major headache in using the Russell Booster is curbing my natural tendency to "DX" and listen to KSL, Salt Lake City, rather than something local to the New York metropolitan area.



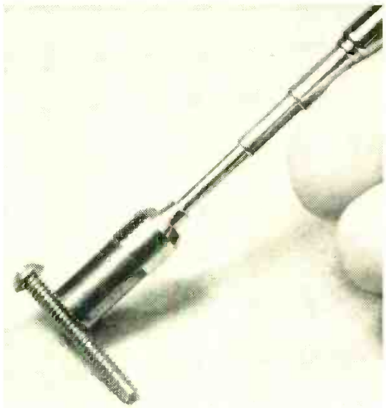
INDUCTIVE COUPLING. The Russell Booster is an encapsulated loopstick with antenna winding. The wires at right are the ground lead and antenna of the Booster. The user simply positions the Booster to insure inductive coupling to the ferrite loopstick in the AM broadcast band receiver.

THE GOOD IDEA—BUT— DEPARTMENT

Some months ago your reviewer received in the mail an "Extendo-Mag" telescoping magnet from United States Magnet. Actually, I shouldn't say "telescoping" magnet since the magnet itself obviously does not telescope, but the chrome-plated arm to which the Alnico-5 magnet is attached extends and retracts. In this particular gadget, the manufacturer has collapsed the Extendo-Mag to 5" and attached a shirt-pocket clip to the barrel. The extended length is just under 18".

Since I am up in the front line when it comes to having a handy magnet around the lab to retrieve nuts, bolts, screws, etc., that have a knack of finding their way into inaccessible areas, I was very pleased to give the Extendo-Mag a trial. I must admit that I'm not too sure why the manufacturer bothered with the pocket clip unless he thought fumble-fingered experimenters might lose the magnet also.

In any case, I tucked the Extendo-Mag in my shirt pocket and went about my day's business. It wasn't too long before I noticed that strange things were happening. It was becoming very difficult to remove my pencil from the same shirt pocket since the Extendo-Mag didn't want to break up the partnership. When I solved that problem, I found I was "wearing" 6-32 nuts and bolts on my shirt front!



TAKE IT WITH YOU. The Extendo-Mag is made to extend to 18 inches or collapse to 5 inches. A pencil clip permits carrying Extendo-Mag in the shirt pocket. Your reviewer gave it a try, but found the over-energetic magnet a Good Idea—But!

This is a good idea, but I don't think too many users will take advantage of the pocket clip.

COMMUNICATIONS

SHORTWAVE LISTENING

Propaganda-Circa 1975—Is there more to the upsurge of interest in facsimile broadcasting than meets the eye (no pun intended)? Is it possible that a few daring shortwave broadcasters are considering the following scene: a Soviet DX'er turns on a receiver but instead of VoA propaganda, it brings forth a subversive anti-Marxist comic strip? In South Africa, an SWL is receiving the daily installment of his favorite news magazine—which by now had been banned from conventional entry into that Republic. And Fidel Castro, who never takes a back seat when it comes to international broadcasting, is beaming the newest Black Panther manifesto into the United States via Radio Habana's transmitters. Unlike direct international TV broadcasts from space, the technology exists to transmit all sort of printed pages. North American DX'ers can readily verify this by tuning 3357 kHz (NSS, Washington, DC) or 5345 kHz (NPG, San Francisco, California) and listen to the insect-like sounds of facsimile transmissions (weather maps) each and every evening. (Submitted by the Short Wave News Service)

SHORTWAVE LISTENING

More on Chicom 1—*Tape recordings sent by various routes to Peking are now being acknowledged by the Academia Sinica (Academie des Sciences de Chine). In a letter dated September 30, 1970, William A. Matthews reports the following text: "The great call issued by Chairman Mao, the great leader of the Chinese people, 'we too should produce man-made satellites' has come true on April 24, 1970. It is a fruitful result achieved by the Chinese people under the guidance of Mao Tsetung Thought and after being tempered in the great proletarian cultural revolution. The music of 'The East Is Red' and the telemetric signals you received were broadcast by China's first man-made earth satellite."*

MEDIUMWAVE LISTENING

New Zealand Goes Into Private Radio—The establishment of the New Zealand Broadcasting Authority with the intention of setting up two broadcasting networks is creating worldwide interest. Radio Hauraki (see POPULAR ELECTRONICS, September, 1970, p 86) operated so successfully that the government—reacting to public pressure—decided to open the broadcasting field to private commercial as well as stations operated by the NZBC. Five stations have now been licensed and Radio Hauraki was the first to go into operation when they signed on at 6:00 a.m., September 26, on 1480 kHz. Mediumwave stations in New Zealand are not permitted commercial programming on Sundays. At this writing the commercials include: 1XW, Radio Waikato, Hamilton (930 kHz), 2 kW; 1XP, Radio Plains, Thames (1020 kHz), 1 kW; 1XK, Radio Waitomo, Te Kuiti (1170 kHz), 1 kW; 1XA, Radio Hauraki, Auckland (1480 kHz), 5 kW; 1XI, Radio International, Auckland (1590 kHz), 5 kW. (Submitted by Arthur Cushen, MBE)

SHORTWAVE LISTENING

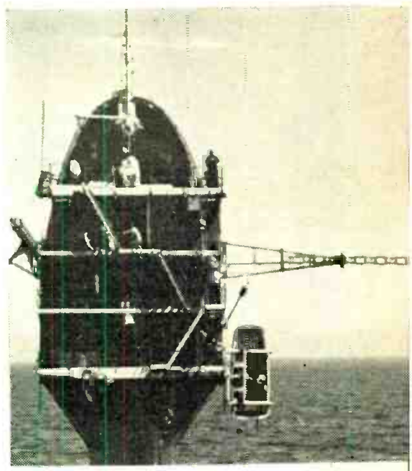
Satellite Broadcasting—*Although most of the talk at the International Broadcasting Convention, London, September, 1970, dealt with TV, a technical paper on shortwave broadcasting attracted the attention of many attendees. The BBC revealed that they had studied the possibility of 11- and 13-meter band international broadcasts from satellites. Regarded as technically feasible, the transmitter need not have more than 1000 watts power output and a satellite could be in a relatively low orbit going around the earth once every 2 or 3 hours. No plans were discussed for putting this scheme into practice, although certain members of the audience had knowing smiles on their faces.*

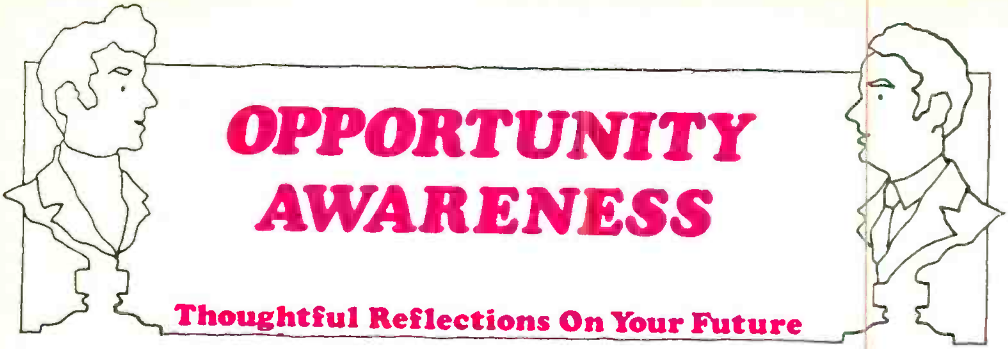
CITIZENS RADIO (CB)

Citizens Band Museum—In one of the most ambitious projects ever undertaken in the short history of CB, the Citizens Radio Association of Rockland, Inc. has announced plans for the construction of the nation's first and only CB historical museum. It is destined to be located on the Association's 40-acre camp grounds in the Catskills in Ulster County, New York. The museum will contain not only historical artifacts, but will house a research library and a "Hall of Fame" to honor CB'ers who have made vital contributions to the furtherance and best interests of CB. Club participation throughout the country is being requested and details are available from Robert Knight, KMD4178, c/o Citizens Radio Association of Rockland County, Inc., P.O. Box 295, Nanuet, N.Y. 10954.

AMATEUR RADIO

Portable and Somewhat Mobile —*One of the biggest challenges of ham radio is packing up your equipment and heading for the open places. Probably the most interesting maritime mobile ham station is aboard "FLIP", the Floating Instrument Platform for oceanographic research. FLIP, a steel tube about 20 ft in diameter and 325 ft long, is towed into position and the bow end is flooded so that it sinks, lifting the aft end out of the water. Shown here in its two positions, FLIP is also the home of several radio hams: Butch Smith, K6GHO; Dave Holloway, K6DHD; and Romeo Vadnais, K6IIX. Conceived at the Marine Physical Lab. of Schripps Institute of Oceanography and funded by the U.S. Navy, FLIP may sometimes be seen at the B St. pier in its home port, San Diego. (Submitted by W6IIX. Photos courtesy Marine Physical Lab.)*





OPPORTUNITY AWARENESS

Thoughtful Reflections On Your Future

Tenth in a Monthly Series by David L. Heiserman

Selling Inventions

Although I have not received a patent as yet, I have designed a circuit for a new kind of burglar alarm. I am not telling anyone exactly how it works, but have tried to sell the idea to several large firms. I always walk away with the idea that these people are laughing at me. What are the chances of getting someone to buy my idea?

● It is very doubtful that a responsible engineering or manufacturing firm would be laughing at you. Most companies treat "walk in" inventors quite seriously.

Contrary to some popular beliefs, however, modern industrial manufacturers don't go out of their way to find new product ideas from the man on the street. Most companies have more ideas than they can possibly produce and many such ideas come from their own expensive research and development labs. For financial reasons, most manufacturers would prefer to keep all the inventing "in the house."

If you have a really good idea, you must be prepared to convince fellow technicians and engineers that the thing actually works. You'll have to reveal every detail and prove with a working model that the idea is as great as you think it is.

The biggest risk in the invention business is not legal, but psychological. Every time you walk into an engineering office, you run the risk of having your ego deflated. Many inventors have fooled themselves into thinking that their brainchild is the greatest thing since the invention of the wheel. Just be sure that your practical judgement has not been clouded by visions of fame and fortune.

The public relations supervisor for a major aerospace firm says that his company tries hard not to discourage people who walk in off the street with a new idea. If the inventor presents all of the details of his gadget and it is not acceptable, the engineers explain why the company doesn't want the idea. If the engineers believe the idea isn't at all practical, they may take the time to point out the technical reasons.

Experience and Income

You keep talking about careers in electronics for beginners, or for technicians that are attempting to advance themselves in the industry. I've been an electronics technician for 22 years. Although I don't have a diploma from any electronics school, I am a high school graduate and would like to have your estimate of what my present salary should be and what I can do to further my career at my age.

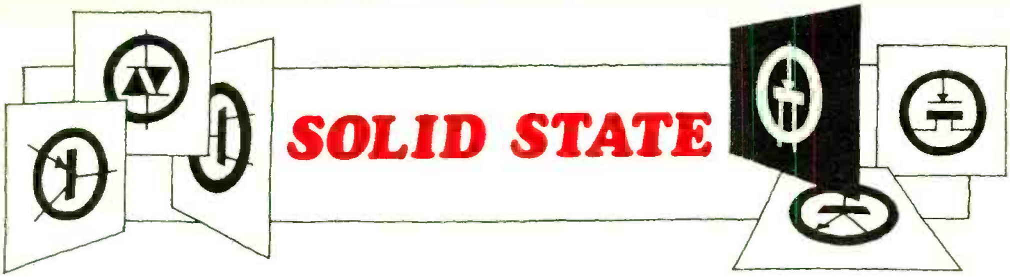
● With your experience your salary should be between $7500 and $12,000 per year—depending upon geographic location. The national average income for technicians with your background is about $9800 per year. By way of comparison, beginners with no formal technical training start out with an average income of just under $6000.

Obviously, your salary will also depend largely upon the type of company you are working for, your responsibilities, and the kinds of products being manufactured or services rendered.

A salary report by the Engineers Joint Council shows that your next 10 years of experience aren't going to increase your earning power by any great amount. Most technicians earn salaries that top out around 20-25 years. Thus, your future here might be considered bleak and restricted to "cost of living" salary adjustments.

Note, however, that technicians who have an Associate Degree (EE) average about $10,300 per year with your experience.

It would appear preferable to take some time over the next four years and get that Associate Degree. Better yet, give serious consideration to the new Bachelors Degree in Engineering Technology. With your experience and a BSET, you could immediately command an $11,000-plus salary.



One Hundred Seventy-Seventh in a Monthly Series by Lou Garner

ACCORDING to the American Automobile Association, over a half-million automobile accidents each year result from "improper overtaking." This frightening statistic might be reduced substantially if a new solid-state detection system developed by Sylvania's Wakefield Development Laboratory (Wakefield, MA 01880) were to come into widespread use.

Designed to meet the specifications of a major automobile manufacturer, Sylvania's Vehicle Proximity Detection System, Model HS-200, will respond to vehicles within 30 feet of its sensor, covering an area slightly larger than a single traffic lane. Its intended application is to alert a driver to vehicles moving into his rear blind zones, as illustrated in Fig. 1.

A passive ultrasonic system, the HS-200 reacts only to those high frequency sounds generated by a moving vehicle, such as road (tire) and engine noises. A passive design approach was selected by Sylvania's engineers (after a thorough investigation of radar, active ultrasonic and infrared detection techniques) when it was found that simple active systems, in general, could not discriminate between real target vehicles and such stationary objects as fences, signposts, tunnels, etc., and, moreover, were extremely sensitive to rain, snow, dust, salt, shock, vibration, and severe temperature changes.

The system's functional block diagram is shown in Fig. 2. In operation, signals picked up by an ultrasonic transducer (microphone) equipped with a directional horn are coupled through a tuned circuit to a high-gain, solid-state amplifier. An agc circuit with a 20-dB dynamic range serves to suppress ambient highway noises, while a signal integrator and threshold detector, together, insure a response only to target vehicles, rejecting shock and similar pulse-like signals. The signal is "cleaned up and fed to a solid-state lamp driver. The output is a 10-volt, 100-mA. dc signal capable of energizing a panel lamp on the vehicle's dash. Circuit parameters are chosen so that the system is insensitive to vehicles traveling at less than 35 mph, thus avoiding nuisance alarms when in bumper-to-bumper city traffic.

In practice, the pickup transducer(s) may

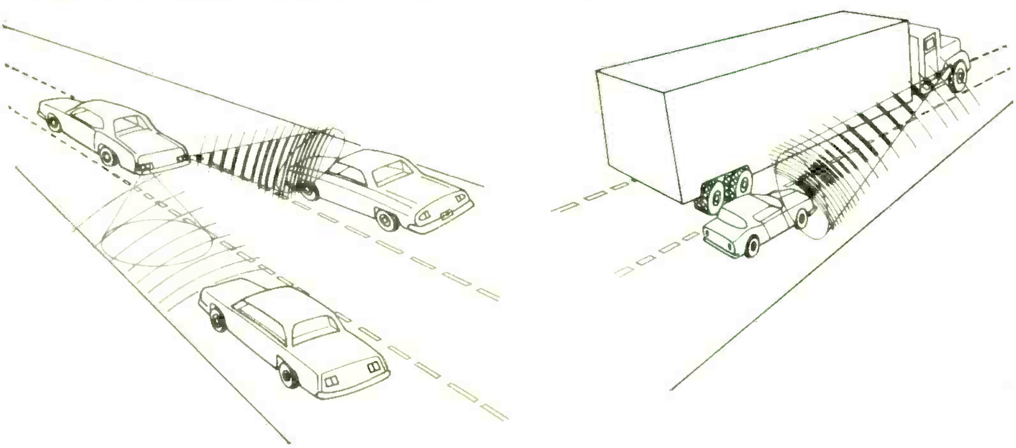


Fig. 1. Sylvania's Vehicle Proximity Detection System alerts a driver to vehicles moving into his rear blind zones. A passive ultrasonic system, it reacts only to high-frequency sounds of moving cars.

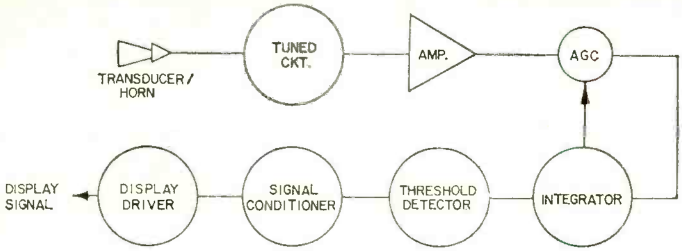


Fig. 2. In detection system, signals picked up by ultrasonic mike are used to activate a visual alarm on dashboard.

be mounted either in a special rear-view mirror package or within the vehicle's rear fender(s) as part of the tail-and-turn-light assembly. The electronic control module may be placed wherever convenient.

Although it was developed using a clever design approach, the proximity detection system is relatively simple. Given the basic block diagram (Fig. 2) and operational philosophy, then, an advanced hobbyist might be able to devise his own functional unit for home construction. At the very least, the design and assembly of a system with comparable performance should prove to be an interesting and challenging project for the serious experimenter.

Reader's Circuit. Submitted by J. L. Elkhorne (76 Roselawn Drive, Independence, KY 41051), the voltage controlled relaxation oscillator circuits illustrated in Fig. 3 may be used in pulse generators, electronic musical instruments, SCR control systems, and specialized test equipment. With modifications, the circuits also may be used as analog-to-digital converters for telemetry and computer applications. Essentially similar, both circuits are adaptations of conventional UJT relaxation oscillator designs.

In the circuit shown in Fig. 3A, control transistor *Q1* is connected in series with charging resistor *R2*. An increase in *Q1*'s base bias voltage reduces its emitter-collector resistance, thus reducing *Q2*'s emitter RC time constant and increasing the output rate. In experimental tests, Elkhorne found that raising the dc control voltage from 0.62 to 1.40 volts shifted the pulse rate from approximately 2 Hz to 3 kHz.

A somewhat different technique for rate adjustment is used in the shunt-control circuit given in Fig. 3B. Here, *Q1* forms a voltage divider in conjunction with series resistor *R2*, thus modifying the slope of *C1*'s charge curve and limiting *Q2*'s maximum emitter voltage. As before, an increase in *Q1*'s base bias voltage will reduce its emitter-collector resistance. In this case, however, the effect is to reduce the oscillator's pulse rate (frequency).

Manufacturer's Circuit. Suggested by Siliconix, Inc. (2201 Laurelwood Road, Santa Clara, CA 95054), the wide-band FET video amplifier circuits shown in Fig 4 may be used in TV sets, radio receivers, r-f remote controls, telemetry equipment, analog computers, oscilloscopes, signal tracers, electronic voltmeters, counters, or in virtually any application requiring an amplifier stage with a high input impedance, a low input capacitance, and a broad frequency response.

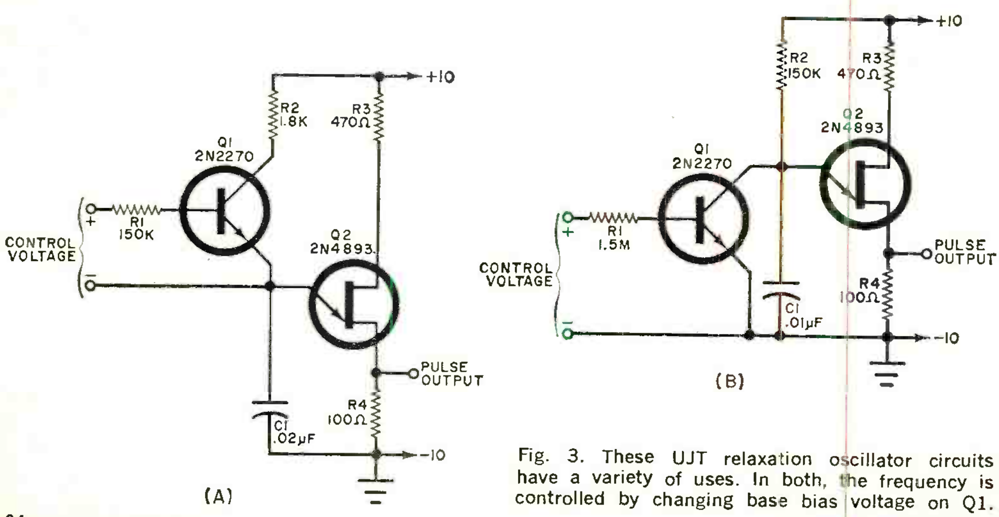


Fig. 3. These UJT relaxation oscillator circuits have a variety of uses. In both, the frequency is controlled by changing base bias voltage on Q1.

With input impedances of up to 10 megohms, all three circuits employ a type 2N5397 n-channel FET.

The common-source stage shown in Fig. 4A can furnish an average gain of 10 dB with a 70-MHz bandwidth and an input capacitance of approximately 8 pF, assuming a drain-to-ground distributed capacitance of about 2.5 pF (shown dotted as C_d).

Gain is sacrificed for bandwidth in the arrangement shown in Fig. 4B. In common with most source-follower designs, this circuit has less than unity gain (0.96), but its bandwidth is 270 MHz, and its input capacitance only 1.5 pF. As before, C_d is considered to be 2.5 pF.

A bipolar transistor, *Q2*, is teamed with the FET in the final circuit, Fig. 4C, to achieve an optimum compromise between gain, bandwidth, and low input capacitance. According to Siliconix, this circuit furnishes 10 dB gain and has a bandwidth of 90 MHz, while its input capacitance is a mere 1.0 pF. Again, C_d is estimated to be 2.5 pF.

All the video amplifier gain, bandwidth and input capacitance figures are approximations, of course, and may vary somewhat in practical circuits, depending on the characteristics of the individual components used for assembly as well as the skill of the builder in minimizing lead inductances and distributed circuit capacitance.

From the Simple to the Sublime. An essential part of circuit development procedures, breadboard techniques are used by hobbyists and design engineers alike. In practice, an individual breadboard may be as simple as a scrap piece of perf board on which an experimental circuit is wired, or as elaborate as a multi-subsystem rack which is patch-wired to simulate complex process control networks or computer systems.

Recently, we've learned of two commercial "breadboards" which should be of interest to experimenters specializing in solid-state circuitry. One, available in several versions, is of moderate size, quite inexpensive, versatile and easy-to-use. The other is *extremely* small, moderately priced, somewhat complex, and also versatile and easy-to-use—*provided* one has access to (or can afford) a fairly expensive accessory.

The simpler of the new breadboards is illustrated in Fig. 5. Dubbed EXPERI/BOARD by the manufacturer, the Circuit Accessories Co. (514 S. River Street, Hackensack, NJ 07601), these units are offered in six different versions—three 4" × 6" types which sell for a mere $1.95 each, and three 6" × 9" models at $3.75 each. All six versions are similar except for size and pattern and all are essentially etched circuit boards with large pads suitable for lap soldering.

The type 46D1 and its larger companion model, type 69D1, have patterns designed

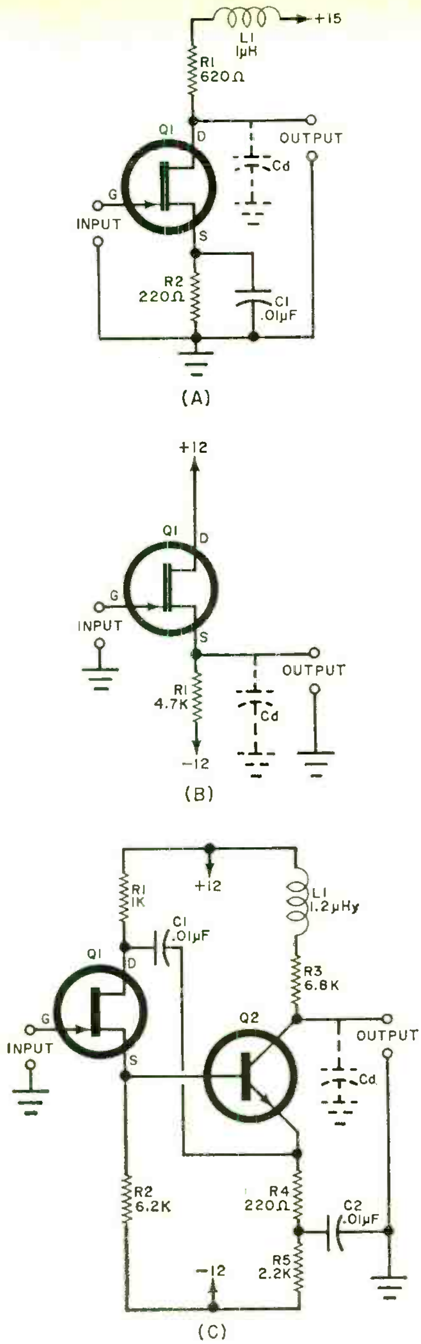


Fig. 4. Wide-band FET video amplifier circuits can be used in any application requiring a high input resistance, low input capacitance and broad frequency response. Circuit (A) has a 10-dB gain with 70-MHz bandwidth; (B) has lower gain but a much higher bandwidth with 0.96 gain for 270 MHz; (C) is optimum compromise—10 dB gain for 90 MHz.

SOLID STATE

(*Continued from page 87*)

for maximum use in breadboarding discrete component circuitry. Type 46-IC-1 and 69-IC-1 have special patterns suitable for 14-lead dual-in-line IC's. Finally, types 46-IC-2 and 69-IC-2 are designed for TO-can type IC's with up to ten leads. The IC models may be used with lap-soldered connections or, if preferred, drilled for standard IC sockets.

Measuring only 0.070 × 0.085-inch (*really!*), making it the smallest we've ever seen, the other "breadboard" comes complete with over 50 integral components, including 6 high frequency *npn* transistors, 2 medium-current *npn* transistors, 2 lateral *pnp* transistors, one common-collector *pnp* transistor, 4 base-emitter junction diodes, one 5.2-volt Zener diode, 30 center-tapped resistors with values ranging from 30 to 200,000 ohms, 4 pinched resistors with values above 25,000 ohms, and 2 junction capacitors.

Identified as the type SG3801 QuikChip by its manufacturer, Silicon General, Inc. (7382 Bolsa Ave., Westminster, CA 92683), the device is actually an uncommitted monolithic IC chip with isolated components and a number of bus bar strips. The units themselves are furnished premounted on uncased TO-100 packages. Relatively inexpensive, the devices sell for less than ten dollars each in unit quantities.

In practice, the designer first develops a schematic diagram compatible with the component values and device parameters on the chip. Next, using the schematic as a guide, he lays out his intended circuit on a scaled-up worksheet which duplicates the IC chip's geometry. Finally, actual circuit connections are made using a microscope-equipped commercial wire bonder. If desired, the completed IC can be capped and sealed using conventional techniques.

If you find Silicon General's little IC breadboards fascinating and find yourself developing the "gotta-try-it-itch," we suggest you resist the urge to order a few until you check your wallet. The small accessory—a standard wire bonder—needed for circuit interconnections can be a wee bit expensive. GTI's (GTI Corporation, Dix Engineering Division, 1399 Logan Ave., Costa Mesa, CA 92626) *Bondsonic* ultrasonic wire bonder, for example, sells for about $2,500.00 *each*.

All in all, a small EXPERI/BOARD and a handy soldering iron can be a lot cheaper way to breadboard, albeit not as intriguing as working with an IC chip!

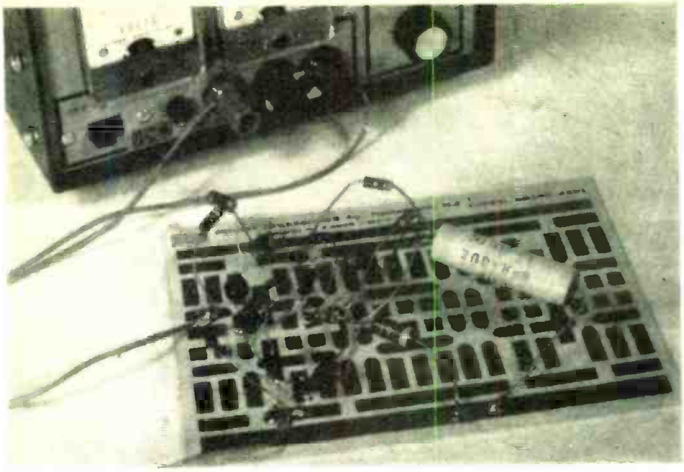


Fig. 5. New breadboards are available in six sizes and patterns and are etched circuit boards with lap soldering pads.

Brochures and Things. Two valuable new Application Notes have been published by Fairchild Semiconductor (Box 880A, Mountain View, CA 94040). Written by members of the company's Systems and Applications Engineering Group, the notes discuss new Fairchild devices and their applications.

Entitled *The 9310-9316 Counters,* Application Note APP-184 (10 pages) describes a new BCD decimal counter and binary hexadecimal counter, multifunctional TTL/MSI devices with three control inputs for mode selection. Suggested applications include counters, multistage programmable counters, up/down counters and cyclic D/A conversion.

The second paper, APP-189, *RF Applications of the FT0601 Dual-Gate MOSFET,* is a 12-page publication by Suleyman Sir which

[1] New Heathkit solid-state 25" ultra-rectangular Color TV with exclusive MTX-5 Matrix picture tube

This is the world's finest color TV . . . and you can prove it to yourself. Compare the standard features of the new "371" to any color TV at any price . . . and you'll agree.
MTX-5 picture tube . . . standard. Developed by Heath engineers in conjunction with leading domestic picture tube manufacturers to provide optimum picture quality. Specially formulated etched glass face plate cuts out unwanted glare . . . gives increased contrast without sacrificing brightness . . . delivers the sharpest, purest, most natural 315 sq. in. of color you'll ever see.
Unique solid-state design . . . under development for over 5 years: 45 transistors, 55 diodes, 2 SCR's; 4 advanced Integrated Circuits containing another 46 transistors and 21 diodes; and just two tubes (picture & high voltage rectifier) combine to deliver performance and reliability unmatched in the industry. Modular plug-in circuit boards permit easier assembly & service.
3-stage solid-state IF . . . standard . . . delivers higher gain for better overall picture quality. Factory assembled & aligned.
Exclusive design solid-state VHF tuner . . . MOSFET design for greater sensitivity, lower noise & lower cross-modulation. Delivers visibly superior color reception. Assembled & aligned.
Automatic Fine Tuning . . . standard. Just push a button and the assembled & aligned AFT module tunes in perfect picture & sound automatically, instantly . . . eliminates manual fine tuning.
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Hi-fi sound output . . . standard. Permits playing the audio from the "371" thru your hi-fi or stereo for better reproduction.
Exclusive Heath owner-service capability built-in. Heath color TV's are the only sets on the market that can be serviced by you . . . without special equipment or knowledge. The exclusive Heath manual, combined with the built-in dot generator and volt-ohm meter make service and adjustment easy . . . and save money.
The GR-371 is the world's finest color TV. Order yours now. **Kit GR-371,** 125 lbs. . . . **$579.95*.** Other solid-state color TV's in 227 & 295 sq. in. sizes from **$489.95*.**

[2] New Heathkit solid-state "Legato" 25-pedal Theatre Organ

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Put a universe of sound in your home today . . . order your new TO-101 now. **Kit TO-101,** 299 lbs . . . **$1495*.** Playmate & Band Box accessories also available.

[3] New Heathkit solid-state 14" portable Color TV

Console performance with portable convenience . . . that's the new GR-169. Heath engineers took the highly sophisticated circuitry of the new GR-371 above, modified it slightly to accommodate the smaller picture tube, eliminated the AFT feature, and put it in a handsome, compact cabinet. The result is a portable that performs better than any portable at any price . . . and better than most consoles as well. Features the unique Heath solid-state chassis for unexcelled performance and long-term reliability.
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It all adds up . . . to the new Heathkit GR-169 . . . the world's finest portable (and one of the world's best consoles too!). Order yours today. **Kit GR-169,** 69 lbs. . . **$349.95***

[4] New Heathkit solid-state 80-10 Meter Amateur Receiver

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Now . . . frequency measurement at a price you can afford. Delivers stable, accurate counting from 1 Hz to over 15 MHz. All integrated circuitry for top performance, high reliability. Automatic trigger level for wide range input without adjustment. Five digit cold-cathode readout with Hz/kHz ranges and overrange indicators give 8-digit capability. Input Z 1 megohm shunted by less than 20 pF for low circuit loading. Order your new IB-101 today. **Kit IB-101,** 7 lbs. **$199.95***

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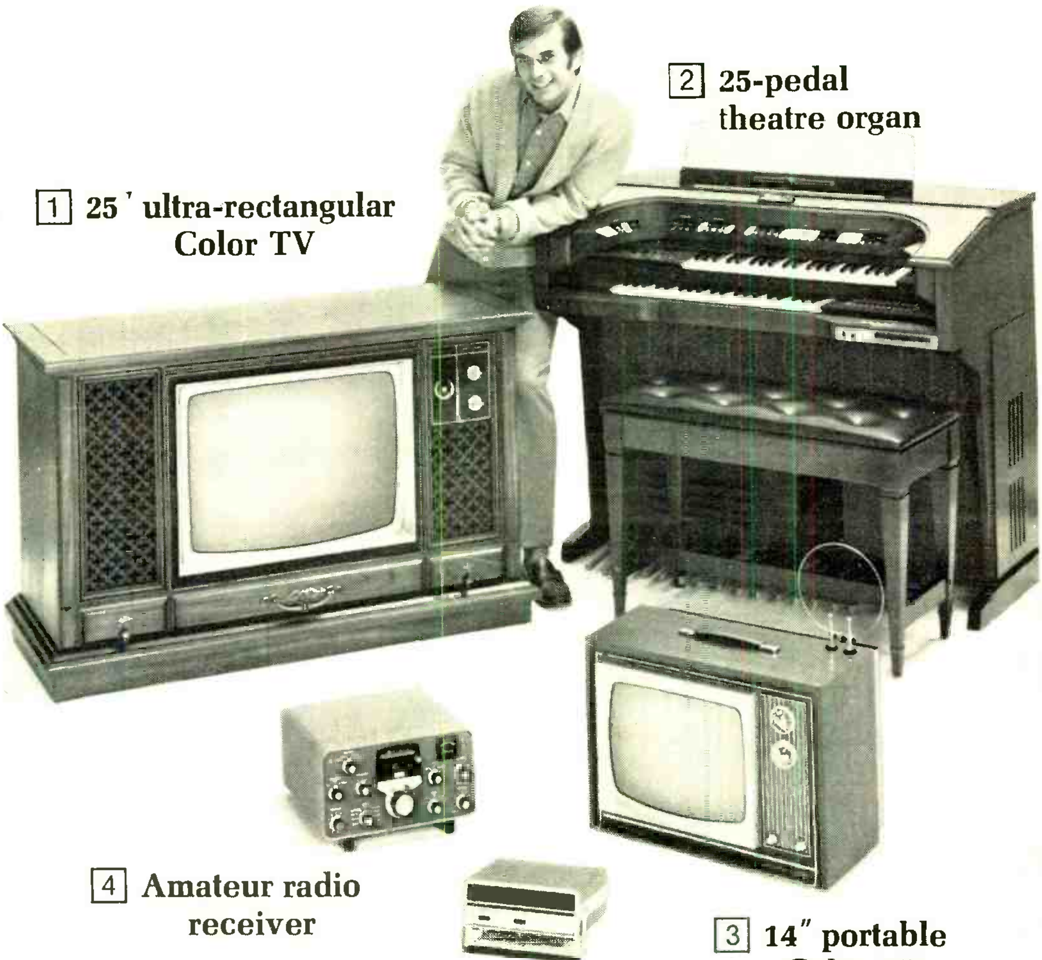

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2 25-pedal theatre organ

3 14" portable Color TV

4 Amateur radio receiver

5 15 MHz frequency counter

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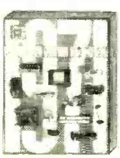

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CIRCLE NO. 8 ON READER SERVICE PAGE

SOLID STATE

(Continued from page 89)

discusses design and performance characteristics of a new MOSFET and outlines the special features that make it ideal for use as a UHF, VHF or FM amplifier, VHF and FM mixer, or i-f amplifier.

Monsanto Electronic Special Products (10131 Bubb Road, Cupertino, CA 95014) has issued the second volume of their new series of booklets, *GaAsLite Tips*. Devoted entirely to opto-isolators, this new 28-page publication covers phototransistor, photodiode, and photoSCR couplers and isolators. Design considerations, applications, and test methods are discussed, with a number of practical circuits included for reference purposes. One interesting section is devoted to the use of opto-isolators in computer interface applications. For a copy of this worthwhile publication, contact your nearest Monsanto distributor or write directly to the company.

Down, Down, Down go semiconductor prices while up, up, up go sales. Despite the nation-wide recession, semiconductor devices continue to fare well in the marketplace compared to vacuum tubes. According to data compiled by the EIA Marketing Services Department, U.S. factory sales of semiconductors showed a 2.0% gain during the first seven months of 1970, compared to a similar period in 1969. In contrast, U.S. factory sales of receiving tubes were down 22.3% from 1969 sales during a similar period. Actually, these figures don't tell the whole story, for some solid-state devices are doing much better than others. During the survey period, for example, sales of monolithic IC's registered a whopping 41.4% increase when measured against comparable 1969 sales, while sales of discrete devices recorded a 5.2% drop. Obviously, the trend is toward an increased use of IC's.

Aside from technical performance, the prime reason for the increasing popularity of semiconductor devices is the continuing drop in prices. When first introduced, for example, Raytheon's original type CK722 "experimenter's transistor" sold for a low, low (for those days) $7.50 *each*. Today, excellent experimenter types are available for about 25¢ each in modest quantities. In another category, Fairchild's original type 709C IC operational amplifier sold for some $64.00 each when introduced a few years ago. Today, the same unit sells for a mere $1.49 in unit quantities and for less than one dollar in 100 lots.

—*Lou*

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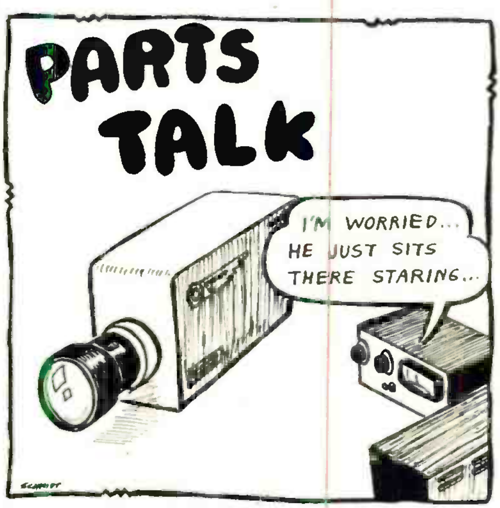
ELECTRO-CULTURE

(*Continued from page 70*)

unless well-watered. Peas and carrots are in this group. Further, electric treatment must be stopped if days are hot and sunny. A simple photoelectric relay circuit, connected in series with the power line, provides adequate control for this purpose.

Note that plants are mavericks in many ways and do not necessarily show uniform yield patterns. Electronically speaking, being living organisms, species utilize the energy contained in the phosphate bonds of adenosine triphosphate (ATP) to drive reactions which lead to maintenance and growth of cells, tissues, etc. This ATP is produced from adenosine diphosphate (ADP) by processes involved in aerobic respiration, fermentation, and electromagnetic bionuclear constituents of photosynthesis. In many ways, plants are *organic* semiconductors and apparently feature electron transport systems which, in higher plant mitochondria, are exactly the same as those for animal mitochondria in ways of generating enzymes.

However, taken together, science has only a vague idea why plants react to applied electro-culture and related methods mentioned earlier. The field is wide open for experimentation and improvement, and it certainly has exceptional hopes for the future. —30—



STEREO SCENE

(*Continued from page* 77)

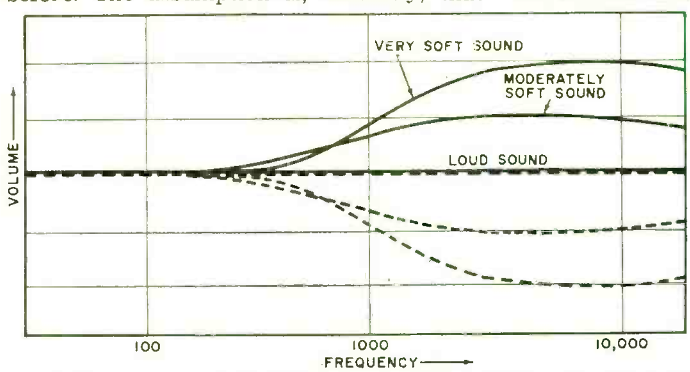
muffled during all but the loudest passages.

Clearly, the Dolby couldn't really get to the root of the cassette hiss bugaboo until somebody started releasing Dolbyized cassettes, recorded with the initial compression on them and all ready for playback stretching. Finally, this is happening. VOX has already released two Dolbyized cassettes, Ampex has announced that future cassette releases will be Dolbyized, and I'm led to believe that other pre-recorded cassette manufacturers are doing likewise.

The fact that un-Dolbyized tapes sound muffled when played via the Dolby stretcher raises a question of concern to the person who doesn't feel he can afford a Dolby B in any form right now: What will the Dolbyized cassettes sound like played back "straight"? Well, frankly, they'll have the hottest-sounding high end you ever heard. The cassette manufacturers are aware of this. They are also aware that many people tend to equate the *amount* of treble with the degree of fidelity, and will consequently think they are hearing higher-fi than ever before. The assumption is, evidently, that people who know better can either cut back on their treble control, for a semblance of fidelity, or can buy a Dolby-equipped cassette machine. In other words, the new cassettes will be aimed at critical listeners, at the expense of the uncritical listeners.

If the general public doesn't rebel at the hot high end on the new cassettes, maybe the industry will carry things a step further and do the same thing with disc recordings, for a Dolbyized disc playback must be heard to be believed! Ticks, pops and swishes practically disappear, and those that remain have the edge taken off them so they are much more easily ignored. If you have a Dolby-equipped recorder, you can get some idea of what Dolbyized-disc surface noise sounds like, by recording some unmodulated but typically noisy grooves (lead-in grooves, for instance) *without* the Dolby in circuit, and then playing it back while switching the Dolby stretcher in and out for comparison. This duplicates the actual situation in that the surface noise, originating *after* the disc is cut, is subjected to Dolbyization only in playback.

Perhaps the Dolby disc has in fact already passed the speculation stage. Rumors within the industry have it that Ray Dolby has developed a C Dolby. Could it be the same as a B, but with rumble-reduction added? Maybe. We shall see. —30—



The Dolby B's effect on frequency response during recording (solid lines) and playback (dashed). Mirror-image playback action exactly cancels treble boost that was applied to low-level passages during recording, restoring the original flat response to sound.

ULTIMATE COUNTER

(*Continued from page 48*)

Signals Required. A positive-going pulse at the clear input, forces all outputs to a low level. Up or down counting can be operated from any positive-going pulse and no shaping or squaring circuits are required as long as the signal is clean and has no spikes or noise pulses. The counter will trigger from pulses as narrow as 20 nanoseconds. The direction of counting is dependent on which input is toggled while the other is kept high. The four data inputs are high level while the load line is kept low.

The four outputs of *IC1* will change to agree with the data inputs independently of the counting input. The borrow output is a pulse equal in width to the count down input when the counter underflows. The carry output produces a pulse equal in width to the count up input when the counter overflows. Cascading of stages is performed as shown in Fig. 4A.

To program a new modulo, the carry output is connected to the load input (see Fig. 4B) and the four BCD data input lines are preset with the required digital code, with A being the first bit, B the second, etc. To obtain a modulo-6, for example, connect the data inputs for a binary four (A = 0, B = 0, C = 1, D = 0). The counter will then start at four, count to nine, and pick up at four again. Of course, the readout tube will have to be wired so that the number 1 lights instead of the 4, 2 instead of 3, etc. Any modulo can be selected merely by applying the correct binary logic to the data input terminals and modifying the readout tube wiring accordingly.

Input for a logic 1 must be 40 μA at 2 volts. The signal source must go below 0.8 volt and be able to sink 1.6 mA from the IC in order for it to go to a logic 0. These values are standard for the Series 74 IC's and represent a fan-in of 1. —30—

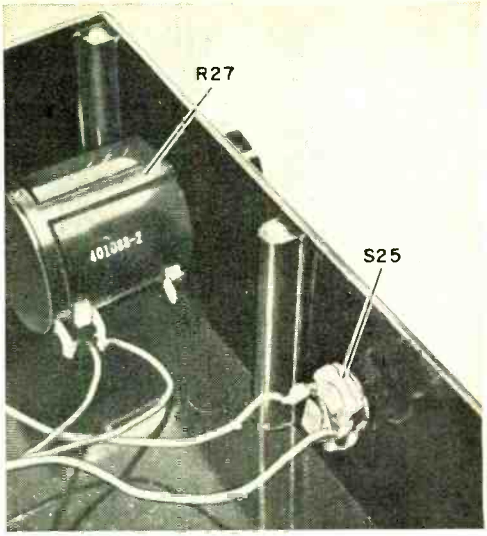
SUBSTITUTION BOX

(*Continued from page* 65)

mounted inside the chassis and the two resistors associated with the bridge (*R25* and *R26*) are mounted on a small piece of perf board which is then attached to the meter terminals. The complete system is wired as shown in Fig. 1. When it is finished, use some form of rub-on letters to identify the controls and switches.

Operation. To use as a substitute resistor, place *S26* in the RESISTANCE position and set the appropriate switches on the front of the instrument to total the desired value. The resistance is available across *J1* and *J2*.

To use the Wheatstone bridge, place *S26* in the BRIDGE position and set *R27* for maximum resistance. Connect the unknown resistor to *J1* and *J2* with appropriate test leads. Depress pushbutton switch *S25* and operate any of the resistor switches. Note the direction and amount of meter movement. If the meter reads "too little," increase the resistance; if "too much," decrease the resistance.



Prototype has a 10-turn potentiometer for close resolution, but a conventional pot may be used.

Continue adjusting the known resistance until a null is obtained on the meter. As the needle is brought nearer zero, adjust *R27* to obtain greater sensitivity. —30—

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INTERFACE

(*Continued from page 10*)

was qualified according to the norms of the industry."

I took a lead from that bit of information and since that time have concentrated on making a decent living in communications. Of course, the work I do requires an FCC license but that is not too difficult to accomplish and possession of such a license opens many doors to the bearer. (Possibly because many employers respect that which they are not able to attain.) I believe earnings in this field can equal those of a typical college graduate serving as an electronics engineer, providing of course he has not worked up into management.

N. JOHNSON, W2OLU
Tappan, N.Y.

MORE OF THE "NEW LOOK"

Your "New Format" is superb. I went temporarily berserk and cut 10 articles out of your last three issues to file in my circuit library. Particularly found "Winding Your Own Transformers" (September 1970) and "Digital Measurements Lab" (November 1970) most welcome!

R. W. CONWAY
Austin, Texas

LEADING OR LAGGING

In your "Quiz on AC Circuit Theory" (December, p 44) there are two possible answers for Nos. 8 and 10. Thus, for No. 8, IC can be 28 mA; and for No. 10, IC can be 25 mA.

E. F. CATEY
Carmel, Calif.

This is true since the questions did not state whether the total currents were leading or lagging.

OUT OF TUNE

Your nomograph for determining "Reflex Enclosure Dimensions" (December, p 64) will be valuable to many of us do-it-yourselfers. But before embarking on a plywood-cutting spree, may I suggest the directions be modified slightly. The line connecting the four columns must be horizontal at all times.

ERIC HODSON
Presidio of Monterey, Calif.

It certainly must!

QRP THING

(*Continued from page 44*)

across the output. The 18-volt battery supply may be made up of three 6-volt lantern cells in series.

With the key up, only transistor *Q1* draws current and the meter indication should be about 5 mA. With the key down, tune *C3* toward minimum capacity and observe how the meter indication rises to 100 mA or more as the driver stage tunes to 7 MHz and *Q3* is fed r-f power. Now, tune *C4* in the pi-section for a dip in current and then retune *C3, C2* and *C1* in that order for maximum current. It should be found that *C1* and *C2* have a very slow-to-respond effect on the output or current drawn from the battery supply. Minor juggling of *C1* will "rubber" the crystal oscillator.

Although maximum r-f power output corresponds closely, in tuning, to the dip (of *C4*) in current, it is more satisfying to measure actual r-f output. This can be done with any convenient directional power output meter.[9]

After tuning up with the 50-ohm dummy load, the transmitter can be connected to a resonant 40-meter antenna fed by a 50-ohm coax cable.

Results. The QRP rig has been the recipient of nothing but good reports (consistently *T9*) and most hams on the other end of a QSO are unwilling to believe that they are listening to a signal running about 0.5 watt output. The entire West Coast of North America has been worked on 40 meters on or close to 7135 kHz—the most-used QRP frequency in the band. —30—

1. "The Camper's Special," H. B. Smith, POPULAR ELECTRONICS, August 1965, p 48.
2. "QRP Special," C. Green, *Electronics Illustrated*, September 1965, p 84.
3. "A One-Watt Rig for 40 Meters," F. L. Dwight, *QST*, November 1966, p 40.
4. "A Transistor 5-Watter for 80 and 40," D. DeMaw, *QST*, June 1969, p 11.
5. "Mini-Mitter: The Ultimate in Miniatures," H. S. Pyle, *73 Magazine*, March 1968, p 18.
6. "Transistor Rig for 40 Meters," E. Marriner, *Ham Radio Magazine*, July 1968, p 44.
7. "The Needle Swings to QRP," H. S. Pyle, *Ham Radio Magazine*, December 1968, p 36.
8. "The Crystal Oscillator," H. D. Olson, *Ham Radio Magazine*, July 1969, p 33.
9. "The QRP 80-40 C. W. Transmitter," D. DeMaw, *QST*, June 1969, p 11.

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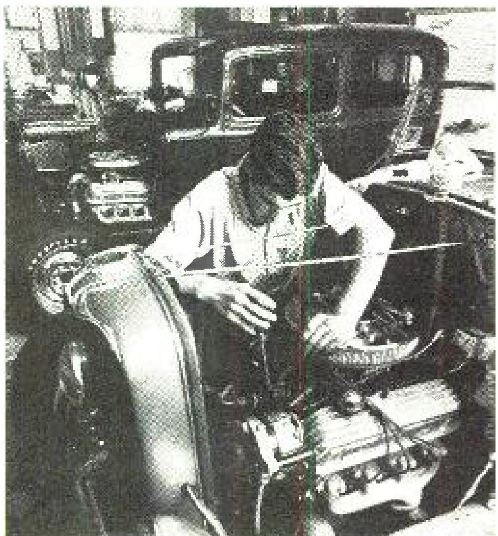

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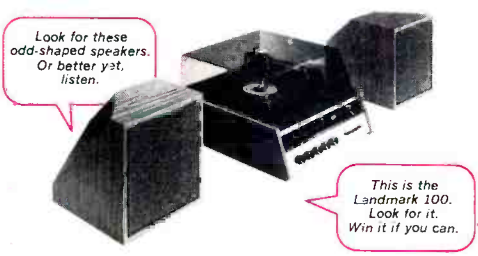

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