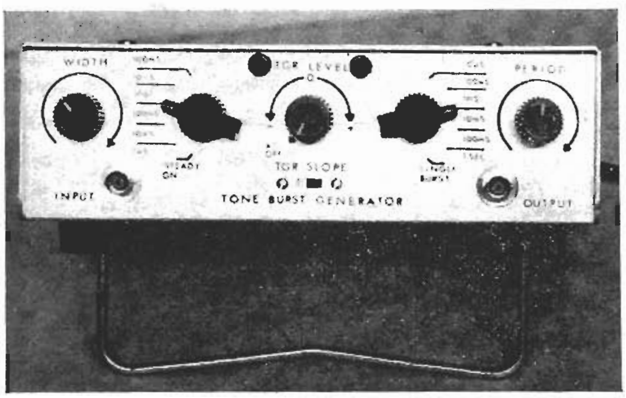
Tune up your stereo: build a TONE-BURST generator

A very special piece of test gear that's a must for your audio test bench. Use it to check out speakers, amplifiers, preamps and other audio equipment. You can build it for about $100.

by TOM ANNES



AMPLIFIERS, SPEAKERS, AND OTHER SOUND COMPONENTS WERE first tested using sine waves, dc transient response checking followed. This is usually done with a dc pulse or square waves. Today, testing with ac transients or tone bursts is becoming more common. After all, a tone burst more closely approximates musical sounds than a square wave.

A tone burst is generated by switching a steady tone on and off with an electronic gate. The control mechanism for this gate must determine how long the gate is open and closed. The bursts should be phase coherent. For example, each burst must start at the same point of a cycle of the gated signal. To do this, we must be able to control the switching of the gate. Commercial units that can do this have been available for several years, but cost $500.00 or more.

Several construction articles have also been published on simple tone-burst generators; however, these units lacked the flexibility to be a really versatile unit. The tone-burst generator in this article is a flexible, high-frequency, high-performance unit that can be built for about $100. It has features that are not available in commercial units. Little goodies like remote single-burst reset, 2-MHz bandwidths at the 3-dB point (the prototype operates to 7.5 MHz), and it can feed coax lines down to 50-ohm impedance.

As with any design, there is a trade off between cost, versatility, and operator convenience. A simple switch or pushbutton can be used as a tone-burst generator but it really isn't very versatile. On the other hand, you can built in every feature you could possibly dream of but who could afford it? This unit was designed and built to give maximum flexibility and versatility per dollar spent. With this economy in mind, all calibration adjustments were eliminated. The features of counted pulses in the burst was deleted from the design because it didn't offer enough versatility for the extra cost. Transistors are used where they give better performance per dollar and ICs where they have performance cost advantage. The proof of the pudding, so to speak, is best told by the specifications and oscilloscope trace photographs.

Tone-burst generators have many more uses than checking acoustics of auditoriums and loudspeaker distortion. When it comes to amplifiers, they are used to check overload recovery characteristics. The newer hi-fi amplifiers that have a music-power rating must be checked with a tone-burst generator because they are unable to sustain full output. I have found this unit great for measuring the bandwidth of tuned amplifiers and the Q's of tuned circuits. It is also ideal as a burst generator in ultrasonic experiments.

This tone-burst generator, because of its wide frequency response and excellent transient response, will find applications in pulse work. For example, it can gate a pulse generator to produce bursts of pulses. If the burst width is reduced to two pulses, you have a pulse-pair generator; a needed item when experimenting with pulse spacing decoders. The uses that this unit can be put to is only limited to the ingenuity of the person using it. For complete details on how to use the tone-burst generator see the August 1971 (next month's) issue of **Radio-Electronics.**

Construction fundamentals

To reduce the chance of error, the following points should be reviewed before you start to build the generator.

1. All ½-watt resistors (except R50) have 0.700" lead spacing. Use a lead bending jig, such as a Triad MK-2, slot No. 8, if possible.

2. All 33-pF capacitors have a 0.250" lead spacing.

3. All components and jumpers are mounted parallel with an edge of the board. No parts are mounted on a diagonal.

4. All transistors (except Q1 and Q2) have their leads in a TO-5 configuration. Q7 will fit the board without bending leads. All other transistors must have their leads bent. The center lead, which is the base lead, will have to be offset from the other two leads by bending it towards the flat on the transistor case.

5. The four JFET's are in the same style case as the other plastic transistors. Bend their leads the same way.

6. Q1 and Q2 are held together (thermally) by a clip. This requires keeping their leads closer together and bending the center or base lead of these transistors **away** from the flat on the transistor case. NOTE: Because of the tight lead spacing of Q1 and Q2, be very careful not to short them when soldering.

7. All plastic cased transistors have the flat part of the case parallel with an edge of the board. The bottom of the cases should be about ¼" above the board.

8. IC1 through IC6 have eight leads each, and can be inserted eight different ways. **Seven of them are wrong.** These IC's have a flat spot on the case next to pin 8. Pin 8 is marked for identification on the board by a dot on the inside of the lead pattern. Space them about 5⁄16" or ⅜" above the board.

9. IC7 has a circle on the top of the case next to pin 1. The board has a dot next to pin 1.

10. IC7 is shown in a socket in the photographs. The IC may be soldered directly into the board. The socket was used in the prototype for convenience.

11. All potentiometers and rotary switches are secured to the panel with a trim washer and a small (½" across the flats) nut on the outside of the panel.

12. On potentiometers with ¼" long bushings, bend over the locating lugs and put on a lock washer before inserting it in the panel. On the rotary switches and potentiometers with ⅜" long bushing, use a nut (large or small) behind the lock washer. Adjust the position of this nut on the bushing to permit only one or two threads to extend beyond the outside mounting nut. If you do this, the locating lug may not have to be bent over.

The unit is built into a custom-made case 8½ inches wide, 2½ inches high, and 7 inches deep. If you choose to build your own case, use .040 inch thick, quarter hard aluminum for the front, back, and bottom. Threaded inserts pressed into the bottom, front, and back permit bolting the front and back to the bottom and attaching the lid. The lid can be made from a softer alloy .063 inches thick. If you make or adapt a case, use the printed circuit board as a template to locate four bolt holes in the bottom of the case to mount the feet and the circuit board.

Start assembling your generator by mounting the feet on the bottom. Secure the screws that come up through the bottom with a lock washer and *two* nuts. The second nut gives added spacing between the circuit board and the bottom plate. The front feet used with the tilt bail require a second bolt which should be just long enough to allow one nut and lock washer on the inside.

Start wiring the printed circuit board by installing the uninsulated jumpers. Use No. 20 or 22 tinned copper wire here. Next, install the diodes, capacitors, resistors, and fuse block. Use lead-bending jigs if you have them to speed the work and make a neater job. Install Q7 with a mounting pad between it and the board. Clip Q1 and Q2 together and then insert them into the board. Install the rest of the transistors and IC's. Q7 and Q16 have heat sinks. Install them last. Install the insulated jumper. Use sleeving over the same type size wire you used for the other jumpers.

Install all wires listed in Table 1. Points 4, W, X, and Y have solder terminals. Wires will be soldered to these points

TONE-BURST SPECIFICATIONS

OUTPUT SIGNAL
A gated replica of the input signal without phase inversion.

INPUT IMPEDANCE
10,000 ohms

OUTPUT IMPEDANCE
About 2 ohms when operating within the dynamic range of the amplifiers. Capable of driving any resistive load from infinity to 50 ohms. Output is short-circuit proof.

INSERTION LOSS (Output On)
Less than 1 dB at 1 kHz when working into 50 ohms.

INSERTION LOSS (Output Off)
Greater than 60 dB, dc to 2 MHz, any load.

BANDWIDTH (50 ohms load)
Dc to 2 MHz (3 dB point) usable to 5 MHz.

TRANSIENT RESPONSE (10% to 90% points)
170 nanoseconds rise and fall time.

OVERSHOOT AND RINGING
Too low to measure.

DELAY (Input to Output)
70 nanoseconds.

BURST WIDTH
Adjustable from 1 microsecond to 100 millisecond, plus steady-on provision to allow adjusting external equipment.

PERIOD (Between commencement of bursts.)
Adjustable from 10 microseconds to 1 second, plus single-burst provision.

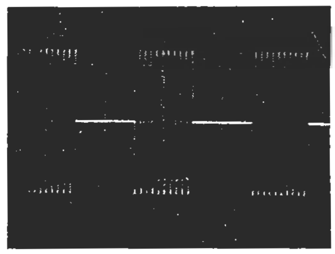
GATE SWITCHING
Switching level and slope selectable with front panel controls. Switching is phase coherent with input signal or external sync.

GATE STATUS
Indicated by red and green "traffic lights" on front panel.

SYNC OUT
Plus 3.6 volts from a source of 640 ohms with output on. About 0.2 volts with output off.

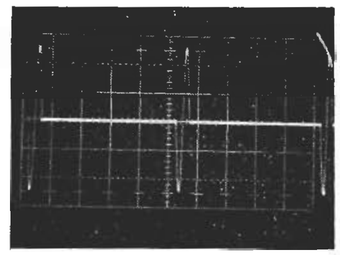
TERMINALS
BNC connectors used for all signal and sync connections, making it compatible with modern equipment.

PHOTO 1



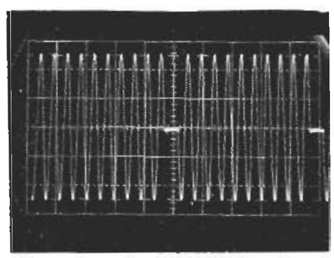
A 10 kHz signal gated 10 cycles on and 10 cycles off. (Sweep speed 500 μsec/cm.)

PHOTO 2



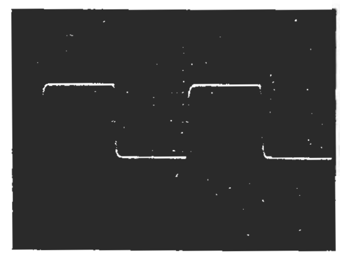
One cycle of a 1-MHz signal gated on every 10 microseconds. Note the clean switching. (Sweep speed 2 μsec/cm.)

PHOTO 3



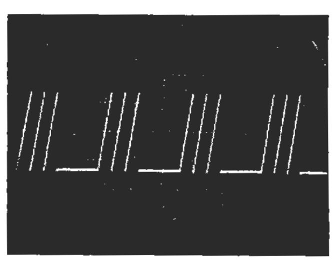
10 cycles of a 1.1-MHz signal gated on every 11 cycles. This photograph shows that the duty cycle of the burst can exceed 90% for some period settings. At least 80% duty cycle is obtainable at any period setting. (Sweep speed 2 μsec/cm.)

PHOTO 4



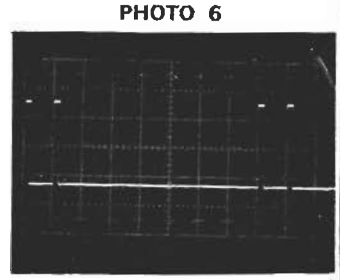
A 100-kHz square wave out of the unit. The rise and fall times (10% to 90% points) is about 170 nanoseconds. Note the clean response, free of overshoot and ringing. (Sweep speed 2 μsec/cm.)

PHOTO 5

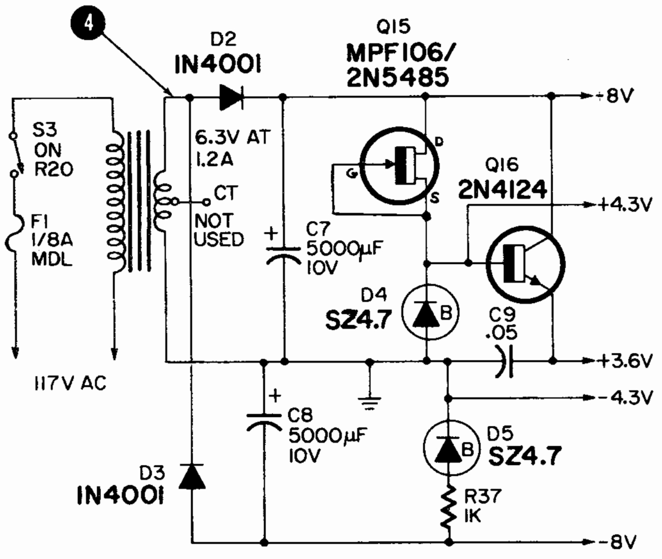


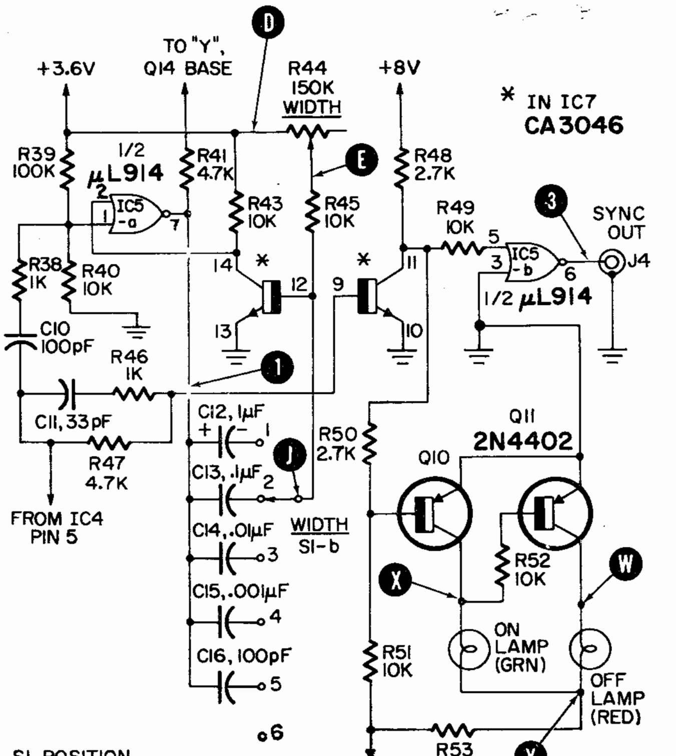
A sawtooth waveform gated 3 cycles on and 4 off. This photograph proves the low distortion of the unit. It also gives an idea of its flexibility.

PHOTO 6



10-microsecond pulses spaced 50 microseconds. This signal was gated by the tone burst generator to produce these pulse pairs every 400 microseconds. (Sweep speed 50 μsec/cm.)





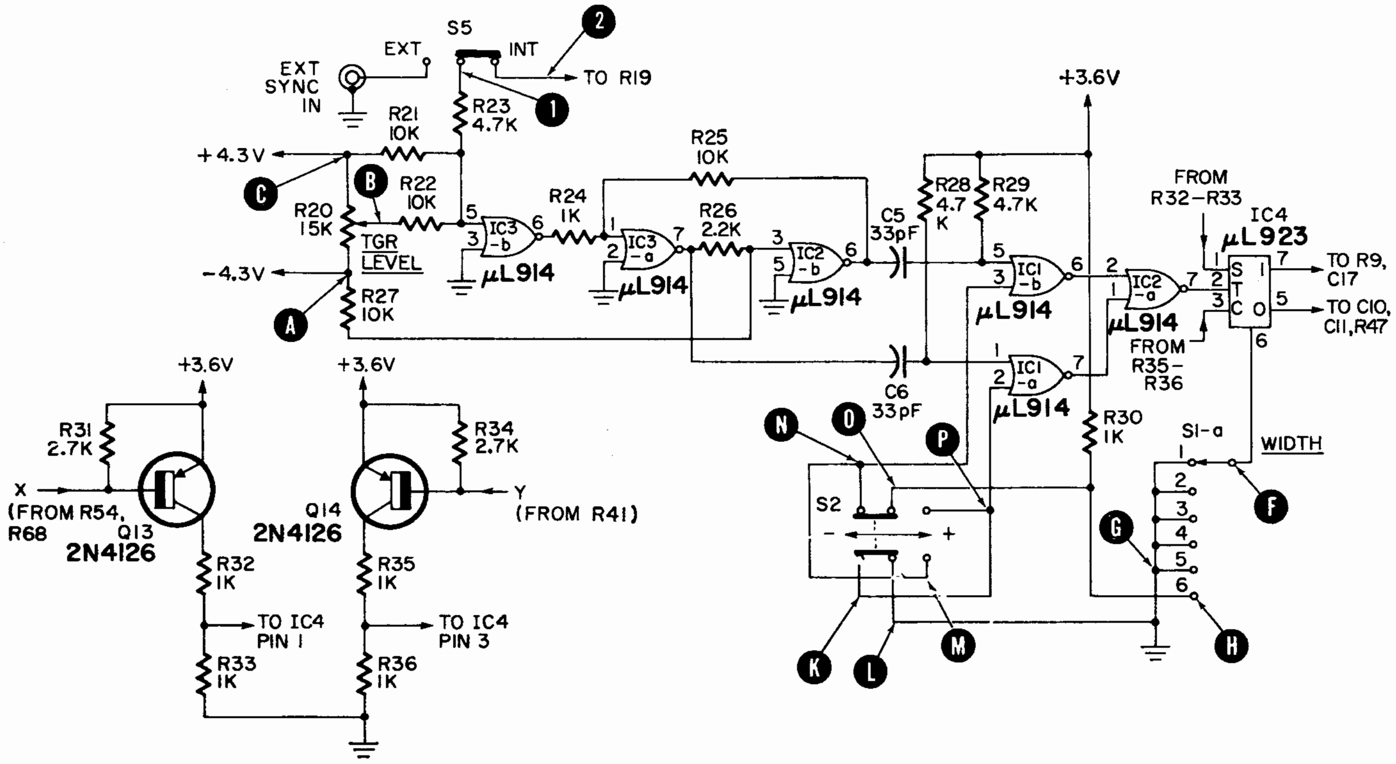
S1 POSITION
1 — 100 msec – 10 msec
2 — 10 – 1 msec
3 — 1 msec – 100μsec
4 — 100μsec – 10μsec
5 — 10μsec – 1μsec
6 — STEADY ON

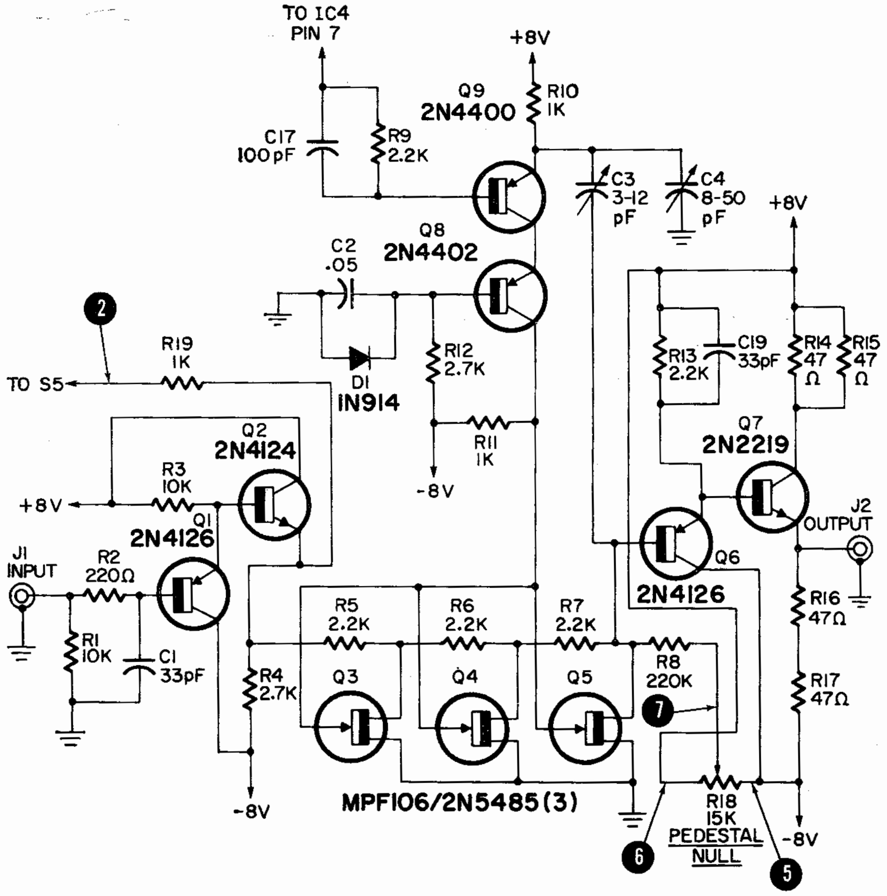
HOW IT WORKS

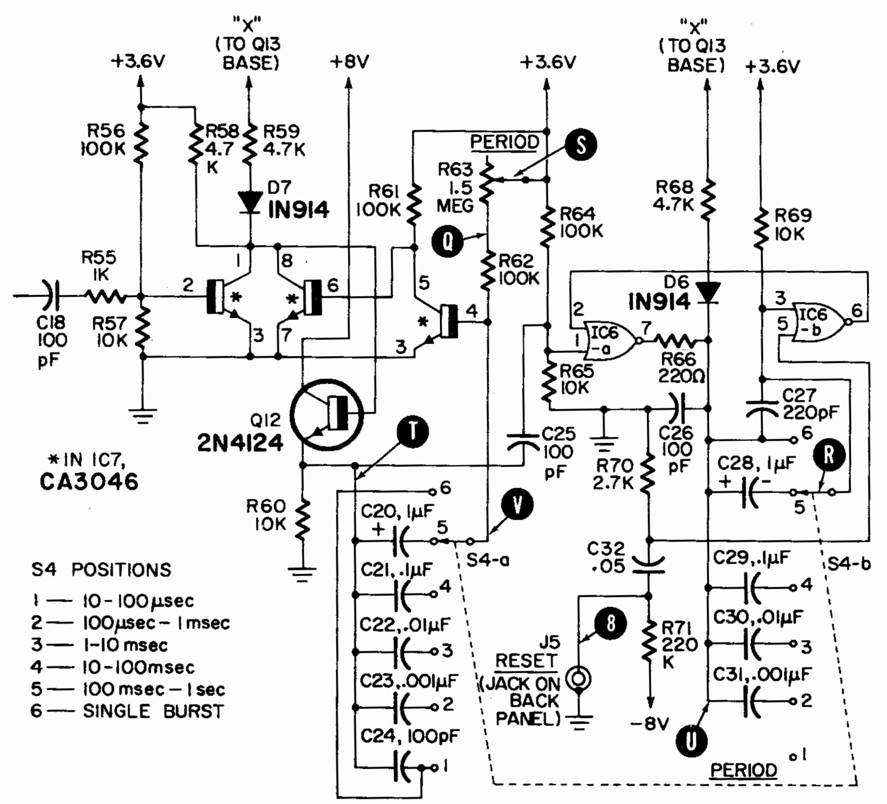
The input amplifier Q1 and Q2 is a buffer amplifier. The output of this amplifier drives the output amplifiers Q6 and Q7 providing Q3, Q4, and Q5 in the shunt gate are back-biased. At zero bias, these JFET's shunt the signal to ground. Each JFET gives 20 dB of attenuation. This gate is back-biased (or zero biased) by the gate driver Q8. Q9 supplies a neutralizing signal for the switching transients.

IC1, IC2, and IC3 form the trigger circuit. With S5 in the internal (INT) position, the input signal is converted into a string of pulses. These pulses toggle the control flip-flop IC4 when IC4 is enabled. The output of IC4 drives the gate driver, the sync out amplifier, and the status-lamp drivers, Q10 and Q11.

Let us start with IC4 in the 1 state. This will turn the output at J2 off. The width and period multivibrators are in their stable state. This disables the lockout transistors Q13 and Q14. A pulse from the trigger circuit causes IC-4 to flip to the 0 state. This back-biases the JFET's in the gate, letting the input signal through to the output. This triggered both the width and period multivibrators. The lockout transistors Q13 and Q14 are now energized and IC4 stays in the 0 state. When the width multivibrator times out, the next trigger from the trigger circuit causes IC4 to flip to the 1 state. The signal at J2 is now turned off. When the period multivibrator times out, IC4 will be enabled. The next pulse from the trigger circuit will cause IC4 to flip and start the same sequence over again.







THESE FIVE SCHEMATICS comprise the various sections of R-E's Tone-Burst Generator. The schematic has been divided into sections for the constructor's convenience. A description of how the circuit works is on the facing page. Note capacitor C18 in the schematic directly above. The dangling lead at the left connects to IC4, pin 5. After you have built and are using your Tone-Burst Generator, drop R-E's editors a note and tell them how you are using your generator. The information will be of value to other readers and we will pass it along in our correspondence columns. Applications are limited only by your ingenu.ty.

PARTS LIST

Resistors ½-watt 10% unless noted

R1, R3, R21, R22, R25, R27, R40, R43, R45, R49, R51, R52, R57, R60, R65, R69—10,-000 ohms
R2, R66—220 ohms
R4, R12, R31, R34, R48, R50, R70—2700 ohms
R5, R6, R7, R9, R13, R26—2200 ohms
R8, R71—220,000 ohms
R10, R11, R19, R24, R30, R32, R33, R35, R36, R37, R38, R46, R55—1000 ohms
R14, R15, R16, R17—47 ohms, 2 watts
R18—pot, 15,000 ohms, ½ watt, linear
R20—pot, 15,000 ohms, ½ watt, linear, with spst switch
R23, R28, R29, R41, R47, R58, R59, R68—4700 ohms
R39, R56, R61, R62, R64—100,000 ohms
R44—pot, 150,000 ohms, 2 watts, linear
R53—47 ohms
R63—pot, 1.5 megohms, 2 watts, linear

Note: Resistors R42, R54 and R67 were removed from the circuit during development, and, for this reason, do not appear on the schematic and parts layout.

C1, C5, C6, C11, C19—33 pF disc
C2, C9, C32—.05-μF 20-V disc
C3—3-12 pF Trimmer
C4—8-50 pF Trimmer
C7, C8—5,000-μF 10-V electrolytic (Sprague 39D or equal)
C10, C16, C17, C18, C24, C25, C26—100 pF disc
C12, C20, C28—1-μF 35 or 50-V electrolytic (Sprague 196D or equal)
C13, C21, C29—.1μF 200-V Mylar (CD WMF201 or equal)
C14, C22, C30—.01-μF 200-V Mylar (CD WMF2S1 or equal)
C15, C23, C31—.001-μF 200-V Mylar (CD WMF2D1 or equal)
C27—220 pF disc
Q1, Q6, Q13, Q14—2N4126
Q2, Q12, Q16—2N4124
Q3, Q4, Q5, Q15—MPF106/2N5485
Q7—2N2219
Q8, Q10, Q11—2N4402
Q9—2N4400
IC1, IC2, IC3, IC5, IC6—μL 914
IC4—μL 923
IC7—CA3046

Diodes

D1, D6, D7—IN914
D2, D3—IN4001
D4, D5—SZ 4.7, 4.7-V, 1-W Zener (Schauer)
S1, S4—2-pole 6-position rotary (Centralab PA-2003 or equal)
S2, S5—dpdt slide switch
S3—on R20

Other Parts

Dual Transistor Clip, Wakefield—239-M
Heat sink, Wakefield—292-A
Heat sink, Wakefield—296-4
1 TO-5 transistor mounting pad
3 insulated terminals tapped 4-40
1 fuse, Buss, MDL 1/8 A
1 fuse holder
2 lamps, Sylvania 6ES
1 lamp cover, red, Sylvania 38001
1 lamp cover, green, Sylvania 38004
1 power cord
1 power cord, strain relief,
1 transformer, Stancor P-6134
1 lug type terminal strip, Cinch-Jones 51B
5 BNC connectors (J1—J5) to mate with holes punched in case
1 fiberglass printed circuit board
4 round pointer knobs
2 bar knobs
1 case

THE FOLLOWING PARTS ARE AVAILABLE FROM:

TOOLS FOR ELECTRONICS
P. O. BOX 2232
DENVER, COLORADO 80201

1 printed circuit board, drilled, with solder terminals—$14.50
Set of semiconductors and heat sinks—$24.00
Finished case with lettered front and rear panel, knobs, tilt bail, lamp mount, feet and hardware—$29.50
Set of electronic parts (switches, resistors, capacitors, etc.) less semiconductors—$45.00
Complete kit of all parts—$105.95
Colorado residents add 3% tax.
Prepaid orders sent postpaid within the 50 states.

during final assembly. Check your work. If you are satisfied, mount the board on the bottom plate by placing it over the screws and securing it with No. 6 nuts without lock washers. Set this assembly aside for now and start on the front panel.

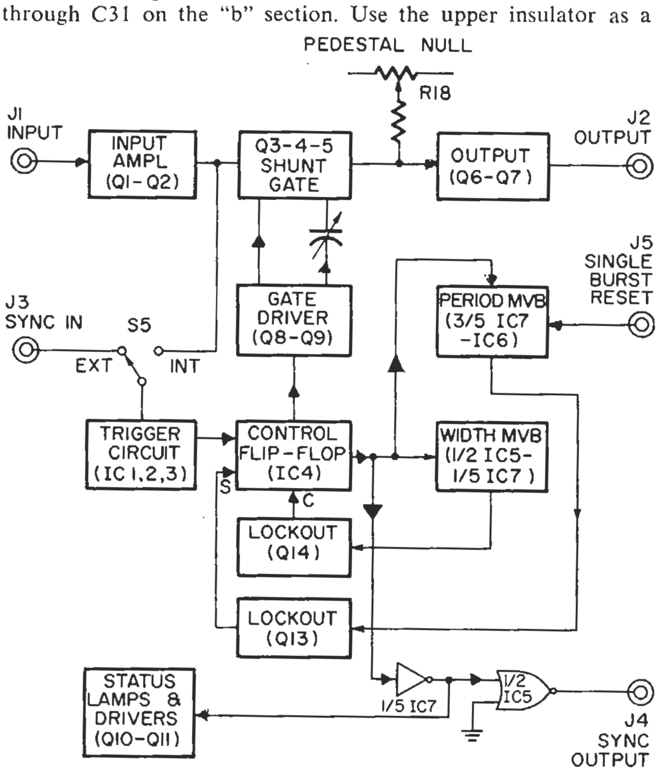
Front panel assembly

Start the front panel assembly by mounting J1 and J2. Next, mount R44 and R63. Make sure you use the **150,000-ohm** potentiometer for the WIDTH control and the **1.5-megohm** pot for the PERIOD control. Mount S2 with No. 2 screws, nuts and lock washers. Insert the GATE STATUS lamps into the clips on the mounting bracket. Place the colored lens caps over the lamps, with green on the left, as seen from the front. Now position this assembly on the front panel with the lens cap protruding from the front panel. Next, mount R20 to secure this lamp assembly.

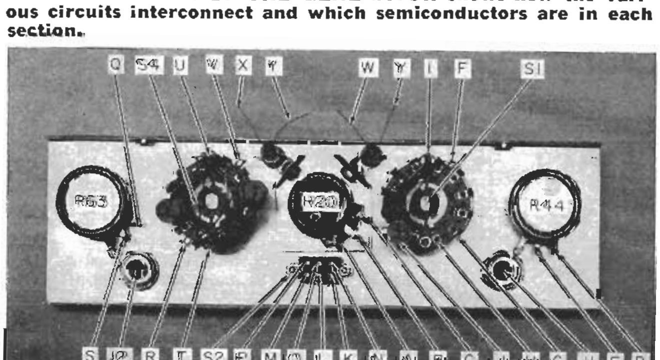
Rotary switches S1 and S4 have six positions; numbered 1 through 6. Position 1 is full counterclockwise on S4 and fully clockwise on S1.

Prepare S1 by mounting an insulated terminal on the upper strut bolt. Use this for a tie point for mounting C12 through C16. C12 is a polarized electrolytic. The positive side must go to the tie point. Strap switch contacts 1-a through 5-a together, then mount S1 on the front panel.

Prepare S4 by mounting an insulated terminal on each strut bolt. Mount the timing capacitors C20 through C24 on the "a" section and use the lower insulated terminal as a tie point. NOTE: Positive side of C20 must go to the insulated terminal. Jumper switch terminal a-1 to a-6. Mount C28 through C31 on the "b" section. Use the upper insulator as a tie point. NOTE: Positive side of C28 must go to the insulated terminal. Mount S4 on the front panel and mount the front panel to the bottom with No. 6 screws. Put on the knobs.



BLOCK DIAGRAM OF THE GENERATOR shows how the various circuits interconnect and which semiconductors are in each section.



INSIDE THE FRONT PANEL. Letter codes are keyed to the schematics and printed-circuit board diagrams to simplify construction.

Wire the front panel to the printed circuit board. The lettered points on the circuit-board overlay match the lettered points on the front panel photo. The leads connected to J1 and J2 should have a hairpin loop in them. This permits raising the board off the mounting screws to free the bottom of the case for removal for servicing the finished unit. The lead dress of wire "V" which goes to the wiper of S4-a is critical. It should lie parallel with the board just above R57 and then be bent 90° so it goes straight up to the switch. Insulate this wire with sleeving. Splice 7" leads on the lamp leads and insulate the splices with sleeving. Connect the leads of the left lamp to points "W" and "Y" and the right lamp leads to points "X" and "Y". Now start on the rear panel.

Mount J3, J4, J5, and S5 on the rear panel. Mount the power transformer with the primary leads out the side facing up. Install a 1-lug terminal strip (Cinch-Jones 51B) under the right-hand transformer mounting nut. Install the power cord with a strain relief. Connect the white lead and a transformer primary (black) lead to the insulated terminal of the terminal strip. Connect the green safety ground and a transformer secondary (red) lead to the grounded mounting lug of the terminal strip. Mount R18. Then attach the rear panel to the bottom with No. 6 screws. Mount a knob on R18.

Wire the rear panel to the printed circuit board. The numbered points on the rear panel interior photo match the numbered points on the printed circuit board overlay. Connect the black lead in the power cord to one side of the fuse holder. Connect the free transformer primary lead to the power switch S3 (part of R20) on the front panel. Now install the final wire. Install an insulated wire from the other lug on the power switch to the fuse holder.

Check your work. If you are satisfied, put a fuse in the fuse holder, put the heat sinks on Q7 and Q16, and start checkout.

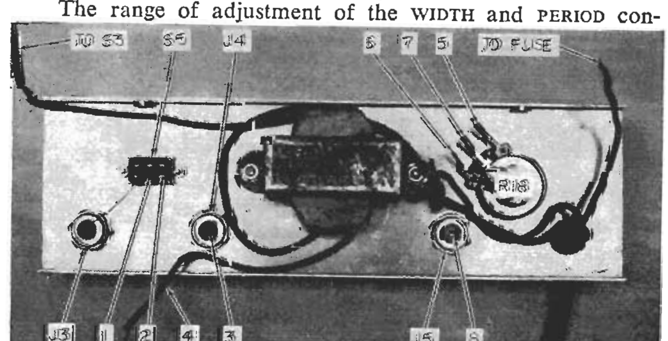
Alignment and checkout

The only adjustments in the unit are switching transient neutralizing capacitor C3 and shaping capacitor C4. These are adjusted to minimize switching transients in the output signal when the input is shorted. To do this, short the input. Feed the tone-burst output to the vertical input of an oscilloscope. Use coax, and terminate it at the scope.

Feed a signal (about 1 MHz) into EXT SYNC IN jack J3 with S5 in the EXT position. Set WIDTH controls for about 5 μsec and PERIOD controls for about 10 μsec. Sync the scope from SYNC OUT jack J4. Adjust PEDESTAL NULL control R18 to eliminate the change in output dc voltage between gate open and gate closed. Adjust C3 and C4 to minimize switching transients in the output. They can be reduced to about 100 mV.

The next thing to check is the centering of TRIGGER LEVEL control R20. Do this by feeding in a sine wave of about 1 to 10 kHz, 5 volts peak-to-peak. Set S5 to INTERNAL and TRIGGER SLOPE to PLUS. Adjust R20 for switching at the 0 volts crossover and note the position of the pointer on the knob. Repeat this with the trigger slope control set to minus. The average position of the pointer should be at 0 on the dial. If it is very far off, you may want to correct it by changing the value of R21. This resistance depends upon the beta of the transistor in IC3-b. (10,000 ohms is about right for units with low betas). Increase the value of R21 if necessary.

The range of adjustment of the WIDTH and PERIOD con-



INSIDE THE REAR PANEL. Here too, letter and number codes shown are keyed to the other diagrams to clarify construction details.

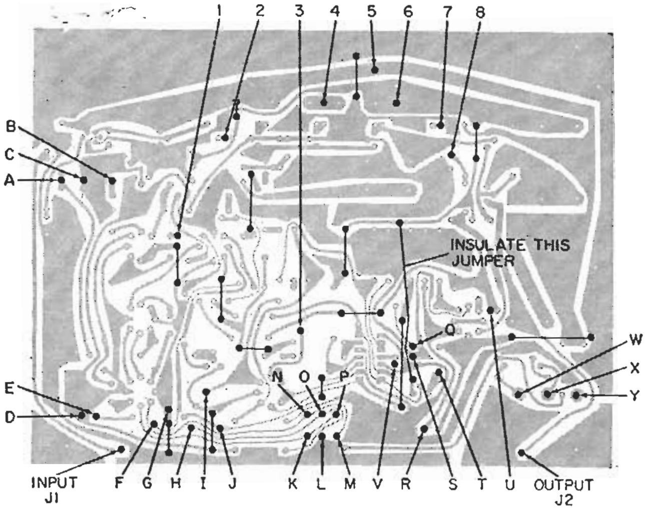
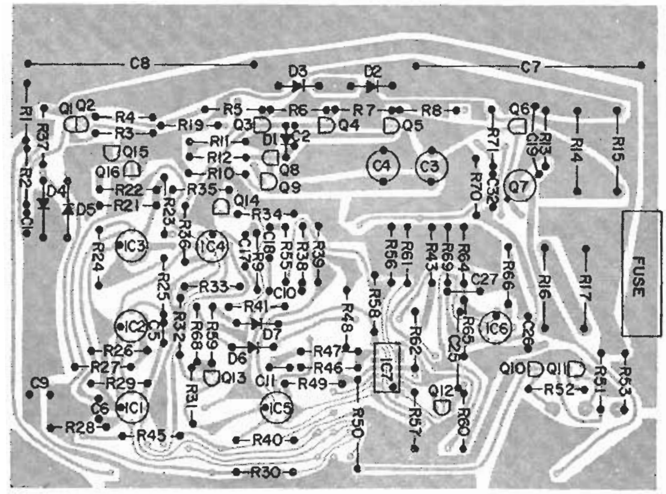


TABLE 1—JUMPERS

A	9″ Insulated	M	7/16″ Tinned	X	Solder Terminal
B	9″ Insulated	N	13/16″ Tinned	Y	Solder Terminal
C	9″ Insulated	O	13/16″ Tinned	J1	1″ Tinned
D	1″ Tinned	P	13/16″ Tinned	J2	3¾″ Ins.
E	1″ Tinned	Q	3″ Insulated	1	1″ Tinned
F	2″ Tinned	R	1″ Tinned	2	2¾″ Insulated
G	1″ Tinned	S	3″ Insulated	3	5½″ Insulated
H	¾″ Tinned	T	¾″ Tinned	4	Solder Terminal
I	2″ Tinned	U	2½″ Insulated	5	3½″ Insulated
J	¾″ Tinned	V	Tinned 3″ Sleeving	6	3½″ Insulated
K	7/16″ Tinned	W	Solder Terminal	7	3½″ Insulated
L	7/16″ Tinned			8	3½″ Insulated



PRINTED-CIRCUIT BOARD DETAILS. Diagram at the top left shows the locations of jumper wires on the circuit board. The table at the left presents jumper details. Above is a diagram of parts positions on the circuit board. Follow it precisely. Below is the circuit board itself, as seen from the foil side. Actual size is 8-inches wide.

trols should be checked for each position of switches S1 and S4. Do this by feeding in a 1-MHz signal and viewing the output on an oscilloscope. The calibration of these controls is not exact. However, you should have adequate overlap on all ranges. If one range is off, it indicates an off-value capacitor. On S4, the capacitors on the "a" side are the critical ones. *NOTE: When making these checks, make sure the* PERIOD *controls are set for a longer time than the* WIDTH *controls.*

The STEADY ON position on the WIDTH control locks the gate open permitting the input to appear at the output. In this mode of operation, all switching and timing is eliminated and no sync pulses are available at J4. Your oscilloscope will have to be synced from this output signal itself. The output should be no less than 5 volts peak-to-peak before clipping starts at 1-kHz input. The input should be greater than the output by no more than 0.5 volt. The green "traffic light" should also be on.

The SINGLE BURST position should turn on the red "traffic light." When J5 is grounded, one burst should appear at the output. The width is dependent upon WIDTH control settings. If the WIDTH controls are set for a long burst, the "traffic lights" will blink; red going off and green coming on for the duration of the burst.

With the output off, residual hum should be about 5 mV peak-to-peak. This hum will have a waveshape resembling a square wave. With the output on and the input shorted, hum will be about 15 to 20 mV peak-to-peak.

The calibration of this unit depends upon the value of the capacitors on S1 and S4-a. They must have the right capacitance and they must be physically small to minimize stray capacitance. The 1.0-μF capacitors are tantalums for very low leakage. Don't use conventional electrolytics. Changing the value of R44 or R63 is another no no!

The most critical part is the printed circuit board. Parts placement and ground paths have to be just right to prevent stray triggering and parastitic oscillations. Switches and controls purchased from parts houses will have to have the shafts cut to length. For ¼ inch long bushings, shaft elngth is ⅝ inch. For ⅜ inch long bushings, shaft length is ¾ inch. These shaft lengths should be satisfactory for most knobs.

Operating hints

The tone-burst generator adds about 15-mV hum to the gated signal. This is a smaller percentage of 5 volts than of 0.5 volt. For this reason, the tone-burst generator should be run at around 5 volts. Use an attenuator on the output if necessary.

Always terminate the coax cable hooked on the output. The output will work into anything from 50 ohms on up. However, an unterminated coax cable is a very high Q resonant circuit. The fast switching of this unit tends to shock excite unterminated coax. If you must work into unterminated coax or shielded cable, insert a pad (6 or 10 dB) between the output and the unterminated cable.

When setting the PERIOD and WIDTH controls, always have the period greater than the width. No permanent harm will be done if this is not observed; however, the output will not make much sense. **R-E**