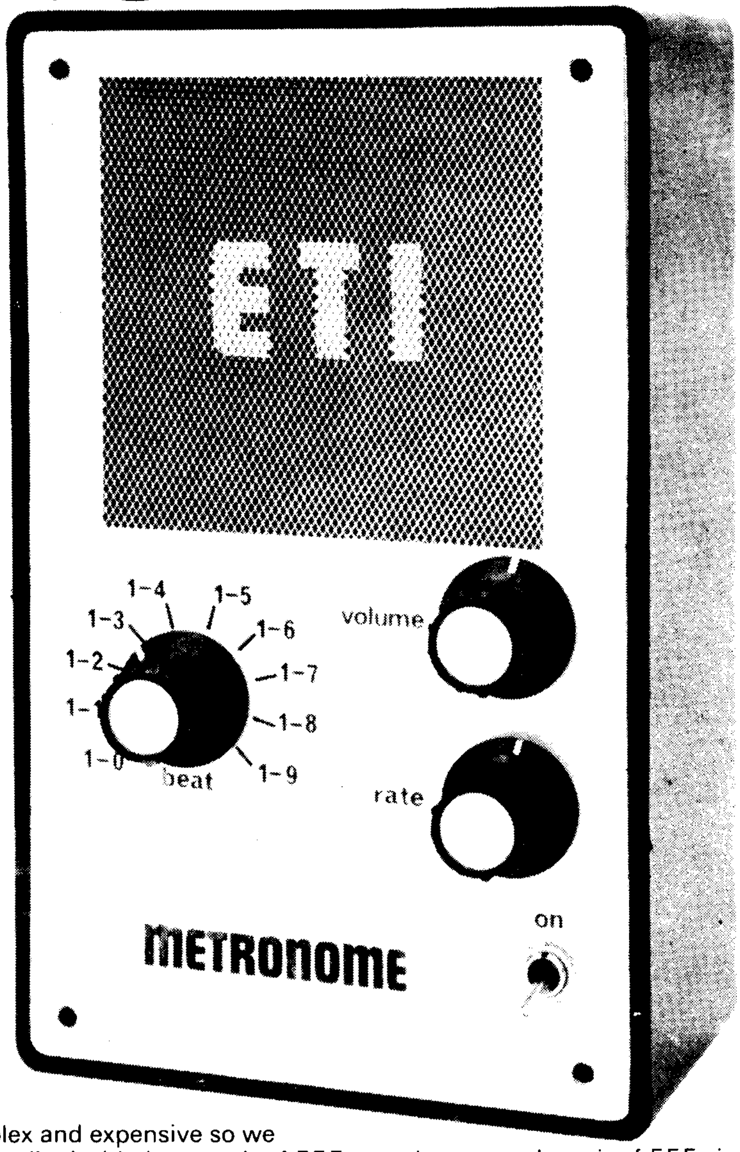
ACCENTUATED BEAT METRONOME

This metronome design accentuates one beat out of every bar to help with complex rhythms



THE THOUGHT of yet another metronome circuit is probably enough to bring tears to the eyes of anyone who has read ETI, or, if you must, any of the other Electronic Magazines over the past few years. The design we present here is, though, a cut above the run of the mill projects that have gone before.

The major advantage of this new circuit is that it will accentuate any particular beat in a bar. Our metronome is designed to help those starting out in music, in whom a sense of rhythm is often lacking.

Accent On Design

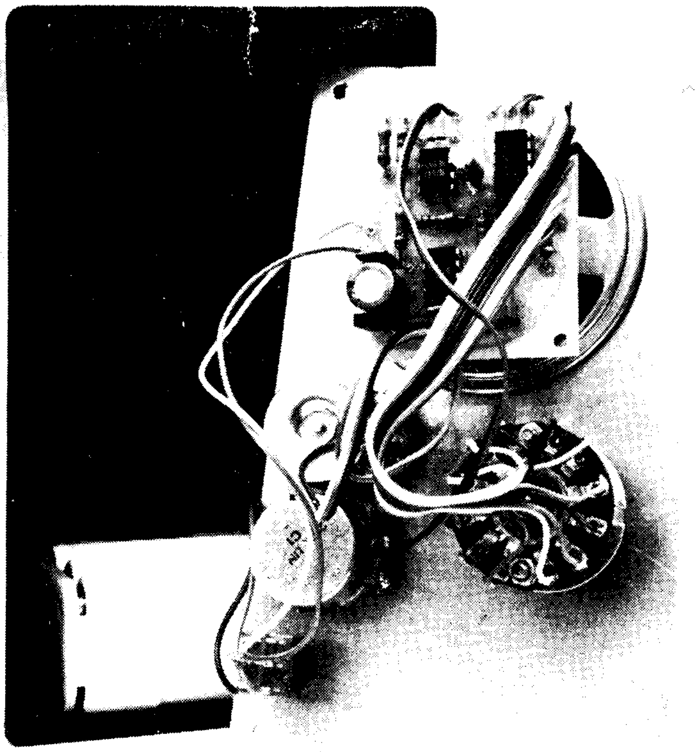
The method employed to produce the beats is to produce a tone burst for each, rather than the simple DC pulse often employed in other designs. The only way to change the sound output in this latter type of circuit, to give the required accentuation, is to change the pulse's amplitude. We found this to be unsatisfactory — hence the tone burst.

Initially we tried a pulsed LC network which, while producing excellent results was a little too complex and expensive so we eventually decided on a pair of 555 timers. For those of you who wonder why we used a pair of 555s instead of the 556 dual timer, just look at the prices of these two devices. For some reason that we cannot understand the 556 is more than twice the price of a pair of 555s. Add to this is the fact that if one half of a 556 is destroyed the whole device is useless, and in most applications and you see why 555s are the best buy.

When faced with the PCB design for this project we considered mounting the wafer switch directly to the board. We finally decided against this approach because of the large ▶

SPECIFICATION

Rate	1 / sec. to 15 / sec.
Beat	Off, 1—1 to 1—9
Output power	
9 volt supply	8 watts peak
Output frequency	800 Hz, 2 500 Hz
Power supply	6 — 15 volts DC



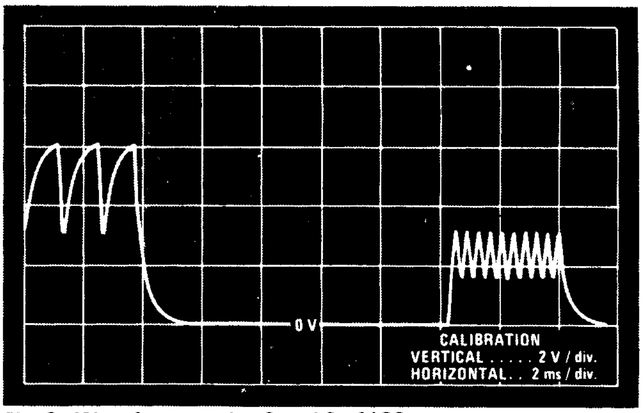


Fig. 2a Waveform on pins 2 and 6 of IC3.

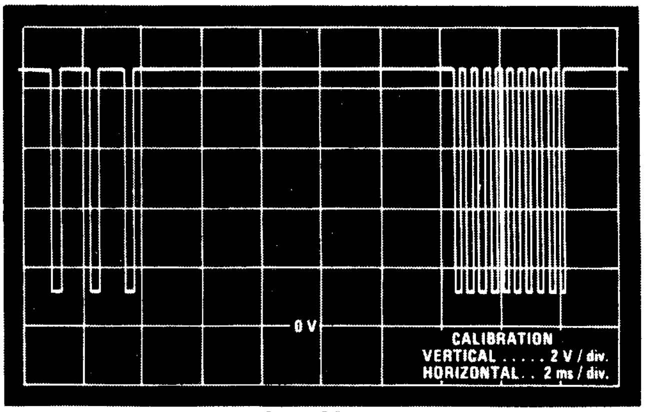


Fig. 2b. Waveform on pin 3 of IC3.

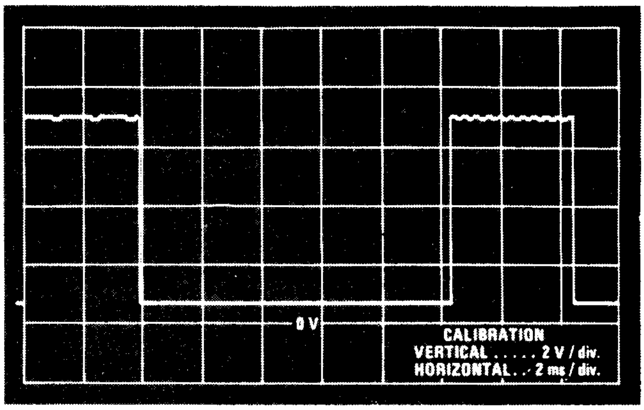


Fig. 2c. Waveform on pin 3 of IC1.
On these waveform diagrams the beat rate has been increased to show the two different outputs available.

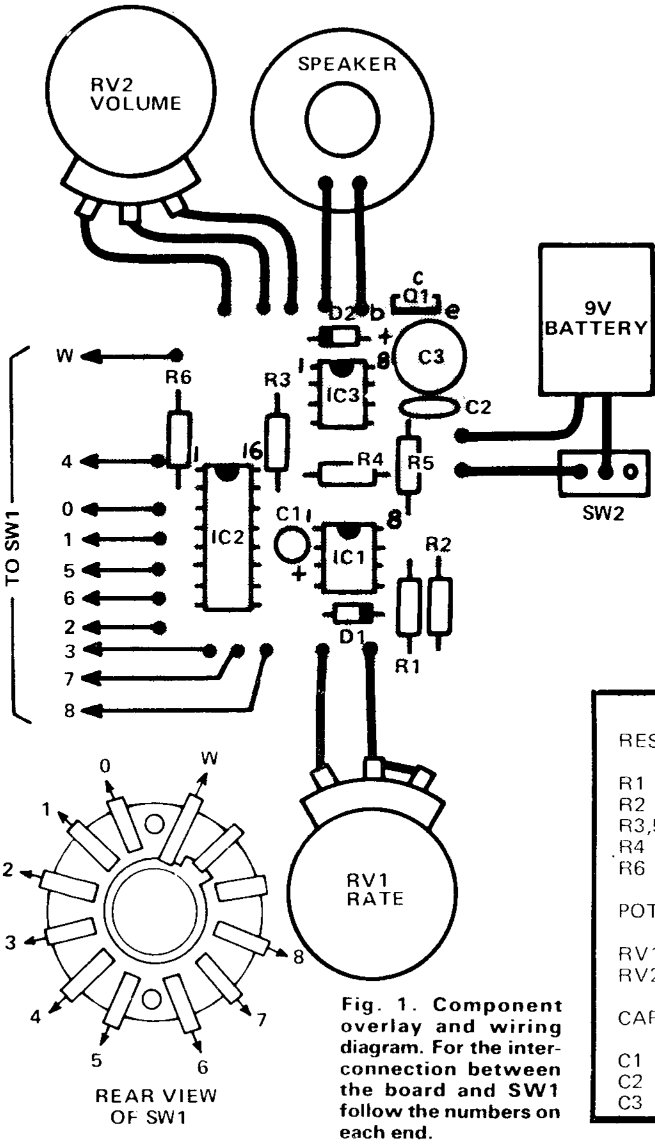


Fig. 1. Component overlay and wiring diagram. For the interconnection between the board and SW1 follow the numbers on each end.

PARTS LIST

RESISTORS all ½ W 5%

R1	2k2
R2	47k
R3,5	15k
R4	1k
R6	4k7

POTENTIOMETERS

RV1	1M lin rotary
RV2	500R lin rotary

CAPACITORS

C1	1u 16 V
C2	22n polyester
C3	100u electrolytic

SEMICONDUCTORS

IC1,3	555
IC2	4017
Q1	BD140
D1,2	1N4004

SWITCHES

SW1	single pole 11 position switch
SW2	single pole toggle switch

MISCELLANEOUS

PCB as pattern, speaker, plastic box, batteries plus holder to suit, 3 knobs.

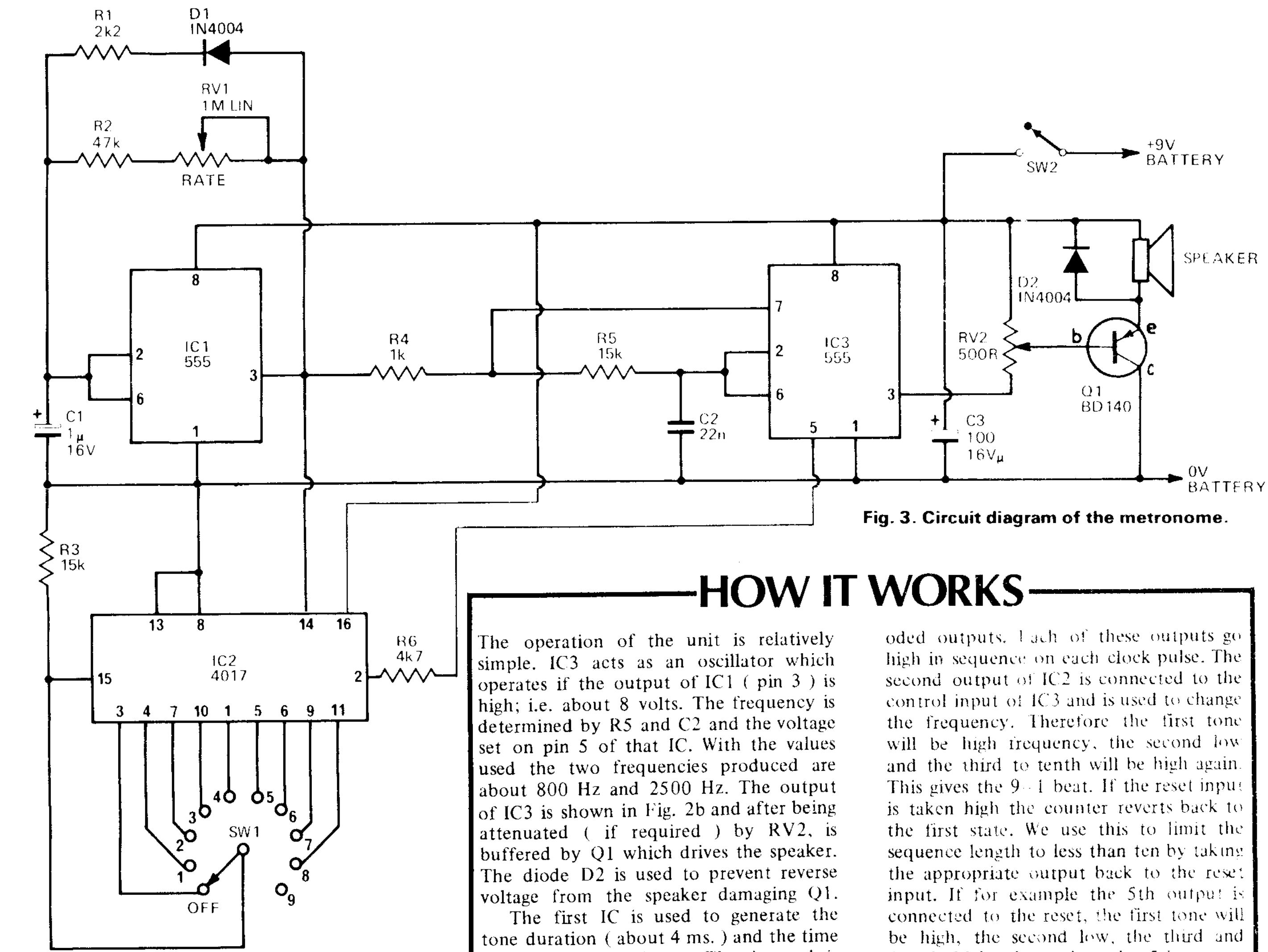


Fig. 3. Circuit diagram of the metronome.

HOW IT WORKS

The operation of the unit is relatively simple. IC3 acts as an oscillator which operates if the output of IC1 (pin 3) is high; i.e. about 8 volts. The frequency is determined by R5 and C2 and the voltage set on pin 5 of that IC. With the values used the two frequencies produced are about 800 Hz and 2500 Hz. The output of IC3 is shown in Fig. 2b and after being attenuated (if required) by RV2, is buffered by Q1 which drives the speaker. The diode D2 is used to prevent reverse voltage from the speaker damaging Q1.

The first IC is used to generate the tone duration (about 4 ms.) and the time interval between beats. The interval is adjustable by RV1 while the tone duration is set by R1. Diode D1 isolates R1 in the interval period. The output of IC1 is shown in Fig. 2c.

The output of IC1 also clocks IC2 which is a decade counter with ten decoded outputs. Each of these outputs go high in sequence on each clock pulse. The second output of IC2 is connected to the control input of IC3 and is used to change the frequency. Therefore the first tone will be high frequency, the second low and the third to tenth will be high again. This gives the 9 : 1 beat. If the reset input is taken high the counter reverts back to the first state. We use this to limit the sequence length to less than ten by taking the appropriate output back to the reset input. If for example the 5th output is connected to the reset, the first tone will be high, the second low, the third and fourth high, then when the 5th output goes to a '1' it resets it back to the first which is a high tone. We then have 3 high and one low tone or a 3 : 1 beat. Actually the 5th output goes high only for about 100 ns. while the counter resets.

BUYLINES

All of the components used in this project should be generally available from your local component shop or from most of the mail order firms advertising in ETI.

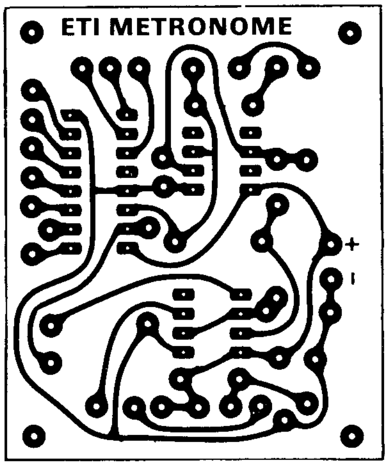


Fig. 4. Printed circuit layout. Full size 60 x 50 mm.

number of different switches available, each with their own connection pattern.

Construction

Assembly of the metronome should cause no problems if the PCB is used. Mount all the components according to the overlay diagram, taking care to orientate the transistors, ICs, diodes and polarised capacitors correctly. We recommend that the 4017 be mounted in an IC socket and that it be the last component installed.

We built the unit into a plastic box with potentiometers, switches and speaker mounted on the front panel. The photographs of the prototype show clearly the layout we adopted.

Beat In Time

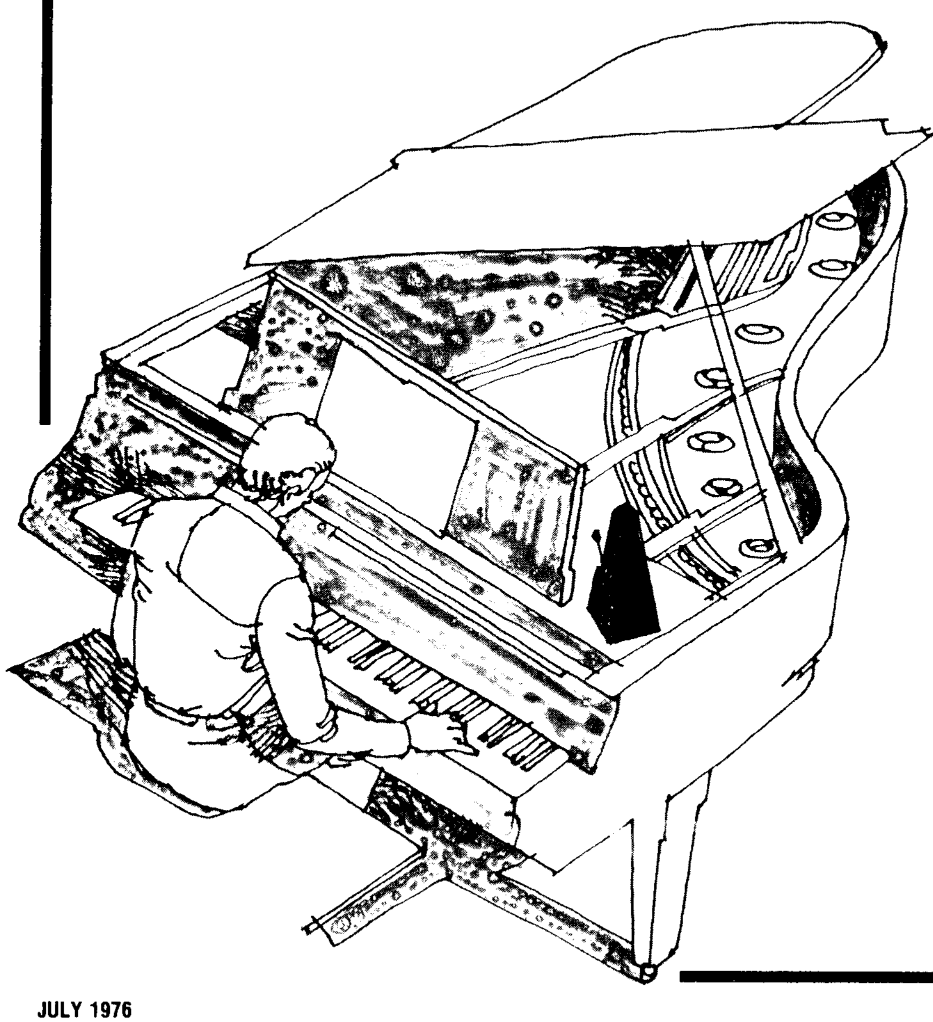
Upon switching on the rate and beat controls should be adjusted to provide the required rhythm. The volume control enables the output power to be adjusted over a wide range.

Hopefully the metronome will soon make itself redundant as a sense of rhythm is acquired by our aspiring musician — keep it handy though, because as we said earlier it will be able to help with the more complex of beats tackled at a later stage. ETI

BY MILTON L. CHESTNUT

BUILD THE ULTIMATE METRONOME

Provides accented beats to make tuning and syncopation easier.



A METRONOME, whether mechanical or electrical in operation, provides some sort of audible signal on a fairly stable time basis. The drawback of such devices is that there is no provision for accenting certain beats in a measure. The Ultimate Metronome described here overcomes this disadvantage by providing accented beats. A switch is used to select accents on the basis of 1 in 1 up to 1 in 7. (1 in 15 is possible with a slight alteration.) Beats are indicated visually (LED) and audibly. The metronome can be built for about $8.

How It Works. As shown in Fig. 1, the main timing signal is generated by *IC1* connected as an astable multivibrator. The length of time that pin 3 is low (near zero volts) is determined by *R3* and *C4*, while *R3*, *R4*, *R5*, and *C4* determine how long pin 3 is high (near +5 volts). By adjusting *R5*, the output frequency can be varied from 30 to 1000 pulses per minute. Capacitor *C5* is used to bypass the external modulation input, while *R1* is a pull-up for the input to *IC2*. The latter is a monostable multivibrator that delivers a pulse whose width is determined by *R2* and *C3*. The pulse width is independent of the input trigger and, with the values shown, is about 250 microseconds. This insures that both the speaker pulse and the *IC3* counter input pulse will always have the same duration regardless of the trigger rate.

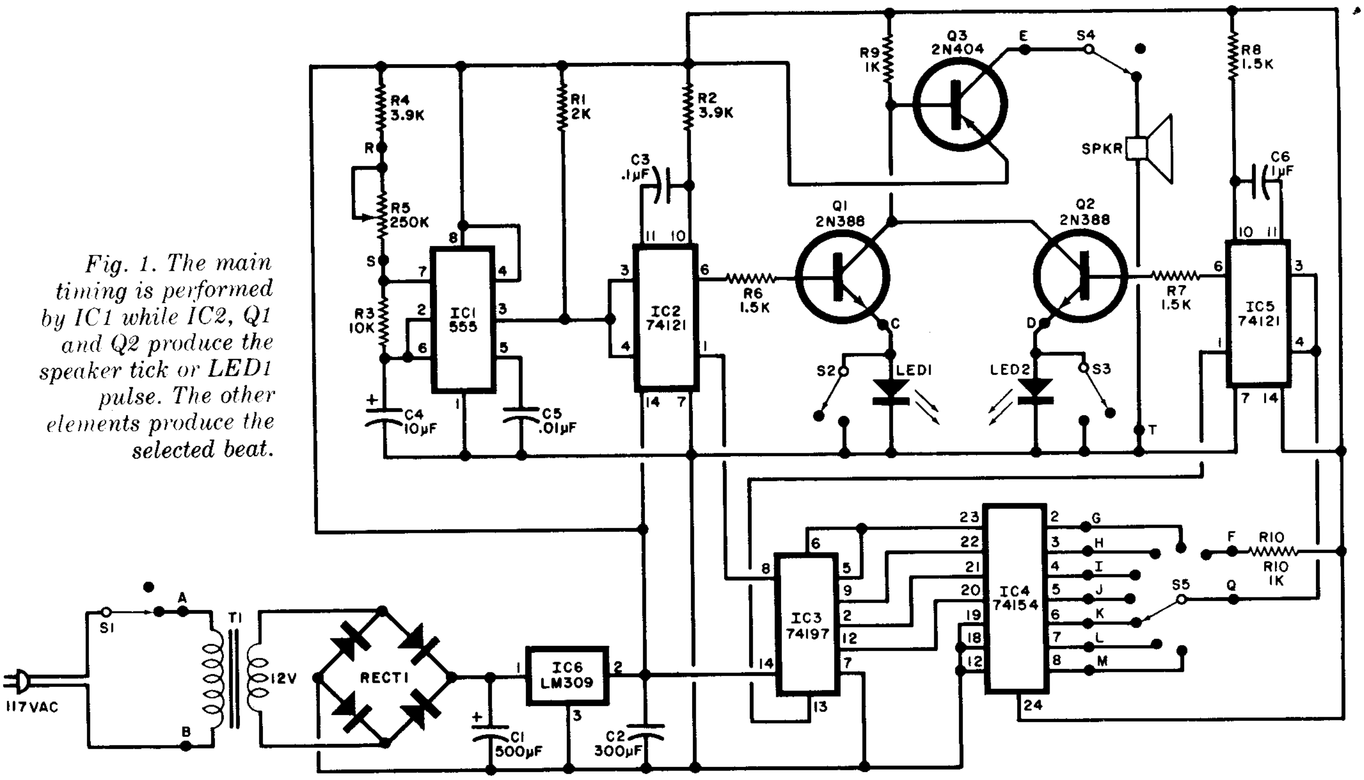


Fig. 1. The main timing is performed by IC1 while IC2, Q1 and Q2 produce the speaker tick or LED1 pulse. The other elements produce the selected beat.

PARTS LIST

C1—500-µF, 16-V electrolytic capacitor
C2—300-µF, 10-V electrolytic capacitor
C3—0.1-µF, 50-V ceramic disc capacitor
C4—10-µF, 6-V low-leakage electrolytic capacitor
C5—0.01-µF, 50-V ceramic disc capacitor
C6—1-µF ceramic capacitor
IC1—555 timer
IC2,IC5—74121
IC3—74197
IC4—74154
IC6—LM309, 5-V, 1-A regulator
LED1,LED2—Red light emitting diode
Q1,Q2—General-purpose transistor npn (2N388 or similar)
Q3—General-purpose transistor pnp (2N404 or similar)
R1—2000-ohm ½-W, 10% resistor
R2,R4—3900-ohm, ½-W, 10% resistor
R3—10,000-ohm, ½-W, 10% resistor
R5—250,000-ohm, linear-taper potentiometer
R6,R7,R8—1500-ohm, ½-W, 10% resistor
R9,R10—1000-ohm, ½-W, 10% resistor
S1 to S4—Spst switch
S5—Single-pole, 8-position, nonshorting rotary switch
SPKR—8-ohm, 2" speaker
T1—12-volt, 300-mA transformer (Radio Shack 273-1385 or similar)
Misc.—Suitable enclosure, line cord, grommet, switch knob, mounting hardware, etc.

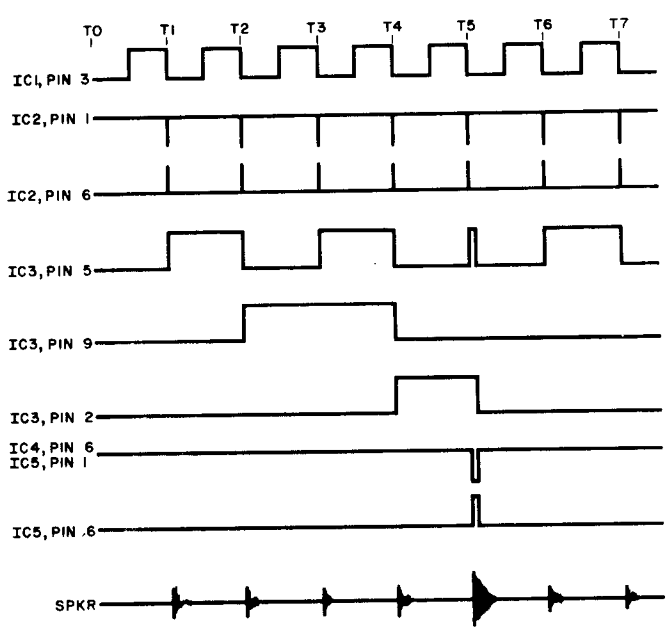


Fig. 2 Timing waveforms for the metronome.

The positive-going pulse from *IC2* (pin 6) drives *Q1* into conduction and, when *S2* is open, causes *LED1* to glow. When *Q1* conducts, it also forward-biases *Q3*, causing a current surge through the speaker (when *S4* is closed). This provides the main beat.

To generate the accented beat, the output from *IC2* (pin 1) is fed to the clock-1 (pin 8) input of *IC3*, a binary-counter/latch. As shown in the timing diagram in Fig. 2, the *IC3* output on pin 5 changes state with each input pulse. Pin 9 changes state every other input pulse, pin 2 every fourth input pulse, and pin 12 every eighth input pulse (not shown in Fig. 2). These four outputs thus make up a 4-bit binary count of the number of input pulses to *IC3*.

The four outputs are applied to *IC4*, a 4-to-16 decoder. The sixteen outputs of *IC4* provide binary combinations from 0000 to 1111 of decimal 0 to 15. With the circuit shown in Fig. 1, only the first 7 of these outputs can be selected by *S5*. The timing in Fig. 2 assumes that *S5* is set to position 5 so that the accent pulse will occur every 5 beats.

The signal selected by *S5* is used to trigger *IC5*, a monostable multivibrator that operates like *IC2* except that the timing components (*R8, C6*) are selected to produce an output pulse of about 1 ms (instead of the 250 μs of *IC2*). When pin 6 of *IC5* goes high, *Q1* is driven into saturation, causing *LED2* to glow (*S3* open) for about 750 ms after *Q1* has stopped conducting due to the main beat. This action causes the speaker to produce a louder tone. When pin 6 of *IC5* goes high, pin 1 goes low, resetting *IC3* to a zero output. The next pulse from *IC2* then counts as the first beat of the next series of pulses. This same action takes place regardless of the beats per minute or the setting of *S5*.

When *S5* is in the F position, the trigger input of *IC5* (pins 3 and 4) is held high by *R10* to prevent any possibility of a stray accented beat. This also permits the use of the circuit as a conventional metronome. With *S5* in position G, every beat is accented to provide a volume increase. As mentioned before, other outputs of *IC4* and other positions of *S5* can be used to select accented beats up to a rate of 1 in 15.

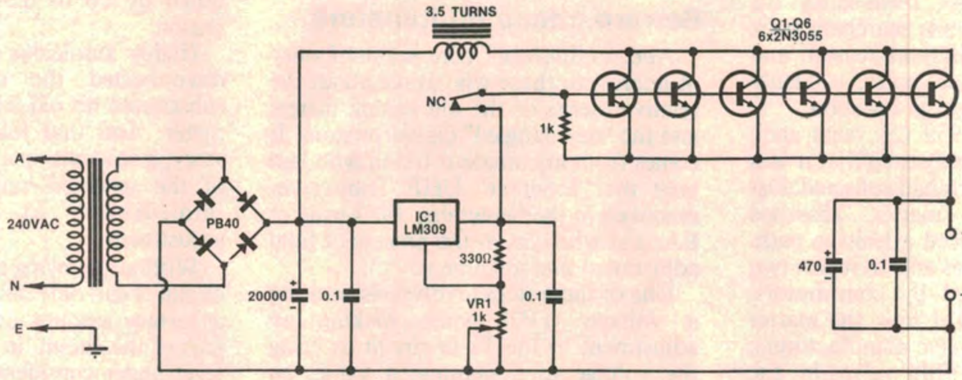
Construction. Any type of construction can be used to build the metronome; and surplus or junkbox components will do. However, the LED's should be selected for similar light output. The size of the transformer given in the Parts List will fit on a pc board. Mount the finished board in a small enclosure with the switches, *R5* and LED's on the cover. Punch some holes in the cover for the speaker.

Calibration. Close *S1* and *S4* and set *R5* to midscale with *S5* in position F. Count the number of beats per minute (checking the operation of *LED1* at the same time). Calibrate the dial of *R5* accordingly. At higher speeds, use the accented beat to count. For example, with a 1-in-5 accent, count 27 accented beats in 60 seconds with *R5* set for 135 beats per minute.

LED1 is for the main beat, while *LED2* displays the accented beat. If you don't need these indicators, they and their associated switches can be omitted. ◈

Circuit & Design Ideas

Interesting circuit ideas from readers and technical literature. While this material has been checked as far as possible for feasibility, the circuits have not been built and tested by us. As a consequence, we cannot accept responsibility, enter into correspondence or provide constructional details.



13.8V power supply

A modified relay is used to provide overcurrent protection in this 13.8V 20A power supply circuit. When the relay trips, it disconnects the drive to the six 2N3055 output devices (Q1-Q6).

Drive current for the output devices is supplied by an LM309 five volt regulator and is nominally 650mA. Although the LM309 incorporates overcurrent protection, this does not operate below about 1.5A. This would correspond to a grossly excessive current in the output of the supply, so some other form of protection is required.

By wiring the relay coil in series with the supply output, the relay is able to operate as a current sensing device. When the output of the supply is shorted, the relay operates and opens the circuit between the LM309 output and the bases of the series pass transistors. As soon as the transistors turn off, the relay releases and the short circuit current again flows through the load.

The relay thus operates and releases continuously until the short circuit is removed. Under these conditions, a short circuit current of about 12A is drawn from the supply.

In the original circuit, 3½ turns of wire sufficed for the relay coil. This figure will vary, depending on the relay used and the trip current. In any case, the original relay coil will have to be replaced.

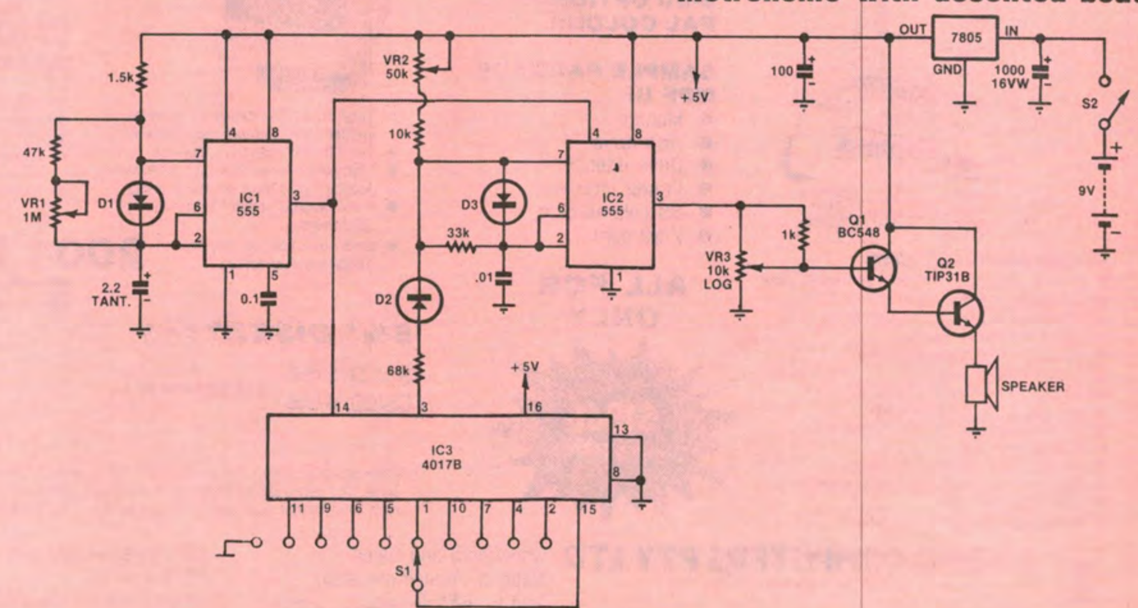
As a means of determining the ampere-turns required to operate the relay, a test winding of say 200 turns can be used. The original relay produced a figure of 70 ampere-turns. Once the figure has been deduced, it is a simple matter to substitute a coil of fewer turns, suitable for the anticipated overload current.

Editor's note: we suggest the inclusion of 0.1Ω/1W emitter resistors for the 2N3055s to ensure equal load sharing. Note also that the type of overcurrent protection offered by this circuit protects the supply rather than any load device.

D. Allen,
Findon, SA.

$12

Metronome with accented beat



Accenting Metronome
P. Hill

The circuit consists of a clock generator determining the beat and a monostable producing the accent.

The clock is formed by IC1a,b configured as an astable. The frequency or tempo is adjusted by RV1. C1 must be a non-polarised type. The clock pulses are fed to IC2. This divides and decodes the clock to produce a high at each output in succession. By feeding one of the outputs via monostable IC1c,d to the reset input, division by one, two, three or four is possible, thus selecting the beat.

IC3 is a CMOS 555 timer, forming a monostable. The on time is determined by C2, R2 and R3. Since R2 only has effect once during the beat cycle, the accent is produced by increasing the on time.