BUILD A MUSICAL

PITCH REFERENCE

INTEGRATED CIRCUITS ARE USED TO DEVELOP TWELVE MIDDLE TONES FOR ORGAN TUNEUP

BY DON LANCASTER

NOTHING MARS THE PLEASURE of playing a musical instrument like having it be out of tune. If your ear is good, you can tune a guitar or a violin using a pitch pipe or a tuning fork. Tuning a piano or an organ is more difficult, requiring complex equipment, lots of experience, and an expert ear.

Tuning a musical instrument of any type is made almost foolproof if you have available a source of musical pitches covering one whole octave. That's what the "Pitch Reference" does. It is an integrated-circuit frequency synthesizer that generates twelve of the middle notes of the equally tempered musical scale to an accuracy better than the best ear can determine and with a stability unattainable by the finest set of tuning forks.

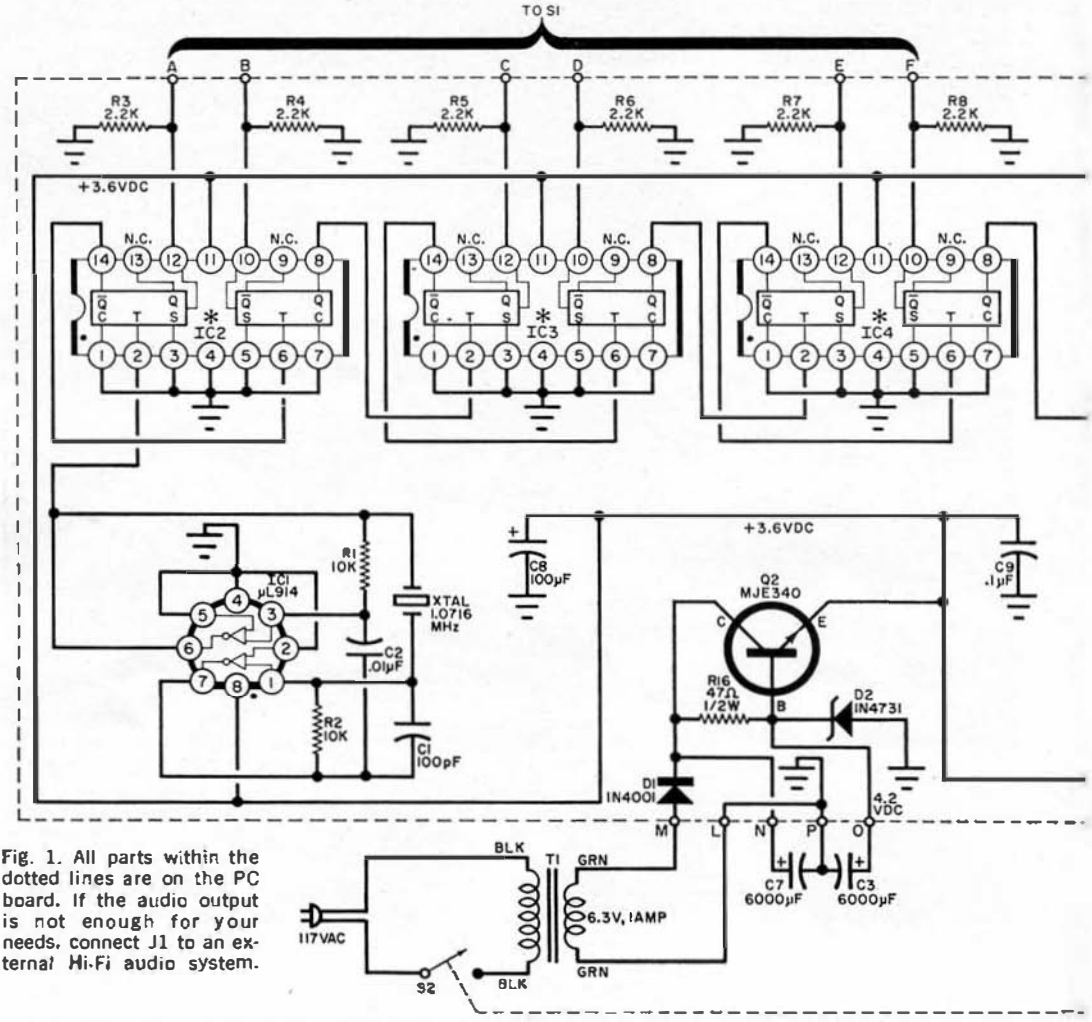
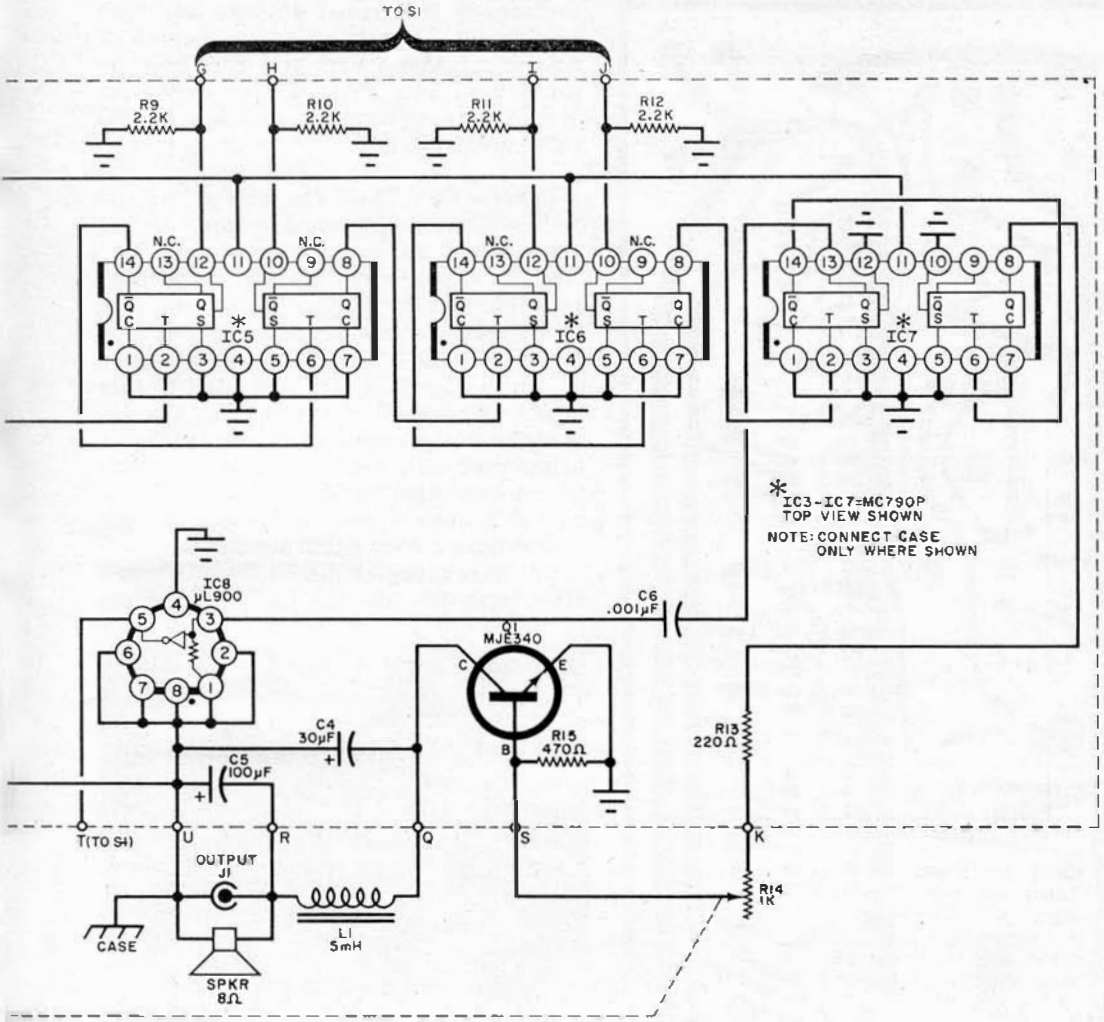


Fig. 1. All parts within the dotted lines are on the PC board. If the audio output is not enough for your needs, connect J1 to an external Hi-Fi audio system.

PARTS LIST

C1—100-pF dipped mica capacitor
C2—0.01-µF mylar capacitor
C3, C7—6000-µF, 10-volt computer-grade electrolytic capacitor (Sprague 36D602G010AA2A or similar)
C4—50-µF, 6-volt electrolytic. Do not substitute
C5, C8—100-µF, 6-volt electrolytic. Do not substitute
C6—0.001-µF mylar capacitor
C9—0.1-µF, 10-volt ceramic disc capacitor
D1—1N4001 diode (Motorola)
D2—1N4731 4.2-volt zener diode (Motorola)
IC1—µL914 dual two-input gate (Fairchild)
IC2-IC7—MC790P dual flip-flop (Motorola)
IC8—µL900 buffer (Fairchild)
J1—RCA phono jack
L1—2.0-mH toroid (Thordarson TOR779 or Triad EA005. Do not substitute.)
Q1, Q2—MJE340 transistor (Motorola)
R1, R2—10,000-ohm, ¼-watt resistor
R3-R12—2200-ohm, ¼-watt resistor
R13—220-ohm, ¼-watt resistor
R14—1000-ohm linear potentiometer with s.p.s.t. rotary switch (S2)
R15—470-ohm, ¼-watt resistor
R16—47-ohm, ½-watt carbon resistor
S1—7-pole, 12-position, continuous rotation, non-shorting selector switch
S2—S.p.s.t. switch attached to R14
Spkr—3 x 5 oval PM speaker, 8-ohm
T1—Filament transformer; secondary 6.3-volt, 1-ampere
XTAL—1.0716-MHz series-resonant crystal
Misc.—Case, dialplate, line cord and strain relief, wirenut, front decorative grill, knobs, mounting feet, capacitor clips, standoffs, terminals, pop rivets, wire solder, backup plate for controls, crystal clip, PC terminals, heat-sink clip and plastic mounting hardware for Q1 and Q2, sleeving, cement, etc.
Dialplate: Genuine Metalphoto Dialplate available from Reill's Photo Finishing, 4627 N. 11 St., Phoenix, Ariz. 85014. In black and silver $2.75; red, gold, or copper $3.25, postpaid in USA. Stock number PRF-1.
Kits and Special Parts: The following are available from Southwest Technical Products Corp., Box 16297, San Antonio, Texas 78216. Etched



and drilled printed-circuit board (part number 154), $3.50. Write for price list on other available components.

The following manufacturers will grind the 1.0716-MHz crystal and encase it in a wire-lead holder. Check for price and delivery time.
Texas Crystals, 1000 Crystal Drive, Ft. Myers, Florida 33901
International Crystal Mfg. Co., Inc., 10 N. Lee, Oklahoma City, Oklahoma 73102
CTS Knights Inc., 101 E. Church St., Sandwich, Illinois 60548

Note: All Motorola semiconductors available from Allied Radio, 100 N. Western Ave., Chicago, Ill. 60680. Related data sheets from Motorola Semiconductor, Box 955, Phoenix, Ariz. 85001. Data sheets and distributor list on IC1 and IC8 available from Fairchild Semiconductor, 313 Fairchild Dr., Mt. View, Calif.

With the Pitch Reference, tuning an electronic organ or guitar is a snap. Add the basic wedges and a tuning hammer, and you can easily tune a piano electronically, listening only for fundamental unison beats that even an untrained ear can easily detect. The Pitch Reference is also dandy for tuning up a band, an orchestra, or even for making intonation studies on a solo instrument. Unlike a tuning fork, the Pitch Reference will "sound off" all day if necessary. Any pitch can be selected by the flicking of a switch and the volume can be adjusted. The device can also be used in physics demonstrations and sound experiments, or as a good entry in a science fair.

The line-powered Pitch Reference is built into a vinyl-clad aluminum case and

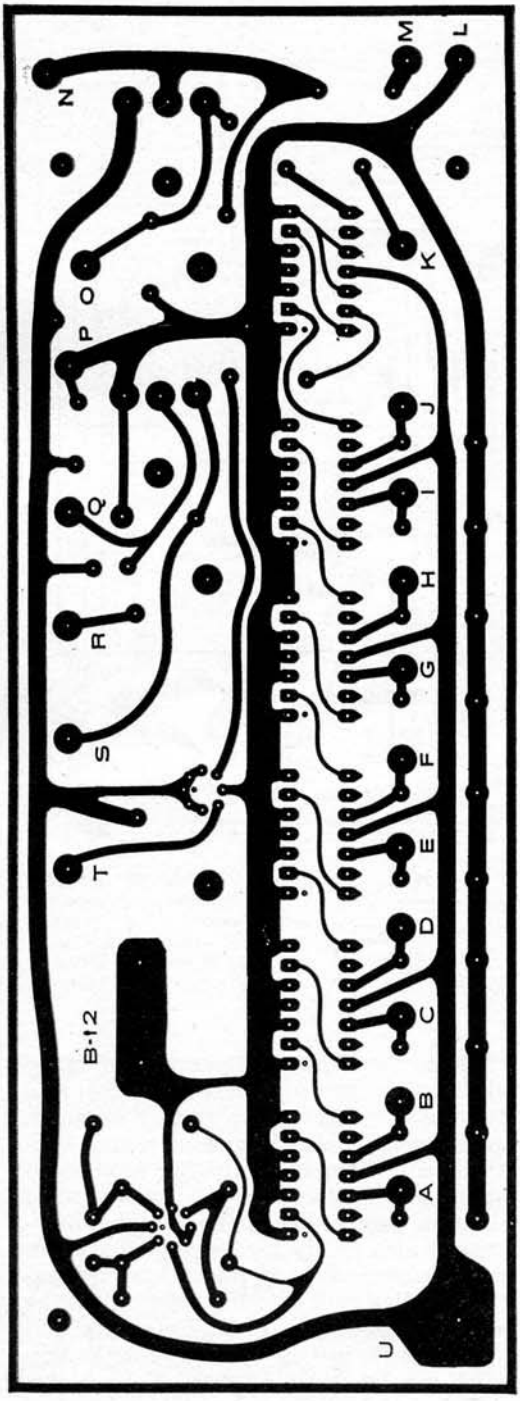
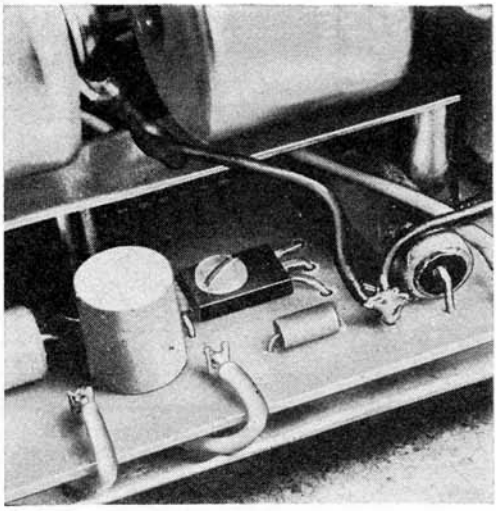


Fig. 2. Actual-size printed-board foil pattern layout. Because of circuit complexity, such a board is necessary to avoid troublesome wiring errors.

contains 8 integrated circuits and two transistors. Depending on the degree of refinement you want, you can build it for $30 to $45. Printed circuit boards, dialplates, complete kits, and any special parts are available.

Construction. The schematic of the circuit is shown in Fig. 1. A printed circuit board is mandatory for this project. You can buy one already etched and drilled (see Parts List of Fig. 1) or you can make your own by following the layout guide of Fig. 2. Drilling details are shown in Fig. 3. A clip is riveted to this board to secure the crystal, XTAL. Insert the components as shown in Fig. 4 being very sure that the IC's are positioned and oriented as shown. Units *IC1* and *IC8* have a flat beside pin 8; the others have a code notch and dot.

The three large holes in the PC board allow you to "double deck" the filter



Transistors are secured to the board metallized-side down, using a plastic screw. Transistors are black, flat rectangles (Q1 shown at center).

capacitors and save some space. Use plastic bolts when mounting *Q1* and *Q2*, and make sure that both are mounted with the metallized side down. A small U-shaped heat radiator should be added to *Q2* for extra heatsinking.

The selector switch should be wired in accordance with Fig. 5. Be extra careful with the wiring; any wrong connection will throw off the frequency by at least one note.

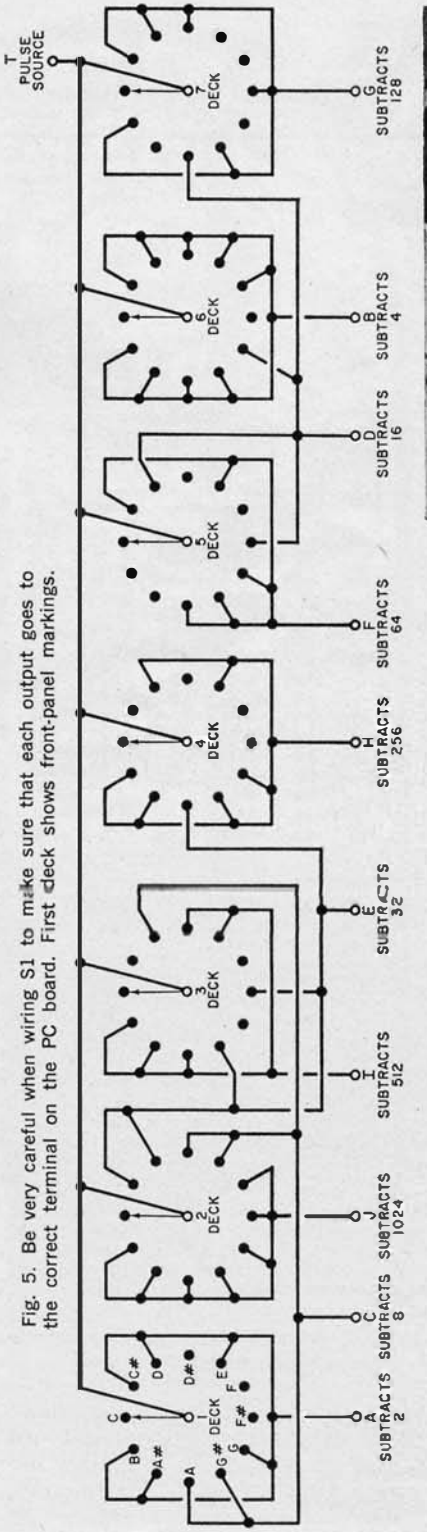
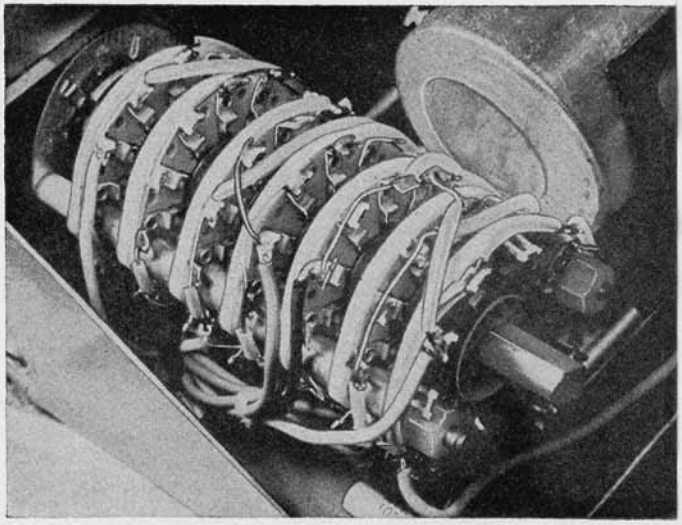
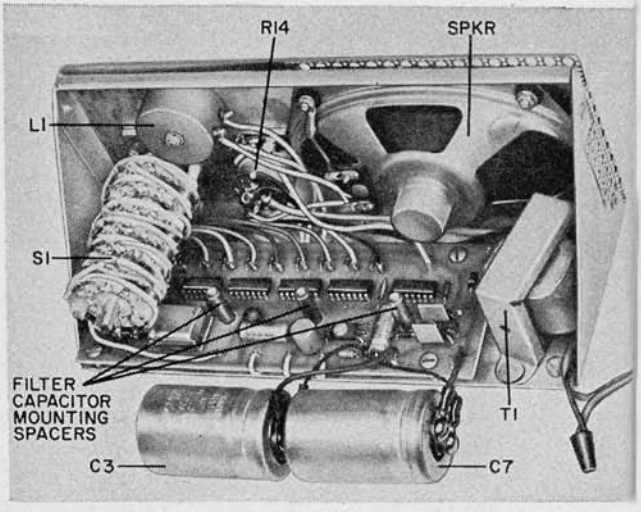


Fig. 5. Be very careful when wiring S1 to make sure that each output goes to the correct terminal on the PC board. First deck shows front-panel markings.

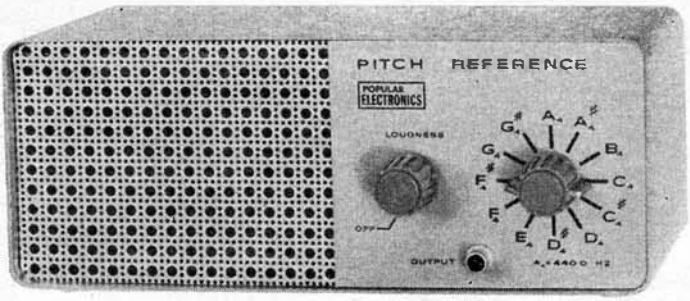


Good wiring practice and neat soldering will ease switch assembly. Use insulated wire where possible.

You can use almost any enclosure you wish, but watch out for any possible mechanical resonance. Fairly large ventilation holes should be provided in the rear to prevent case resonance and any back-pressure effects. The 3 × 5 oval speaker should be shock-mounted using grommets or some other means. Finally, the grill and grillcloth should be glued in place to prevent any possible rattle from vibration.

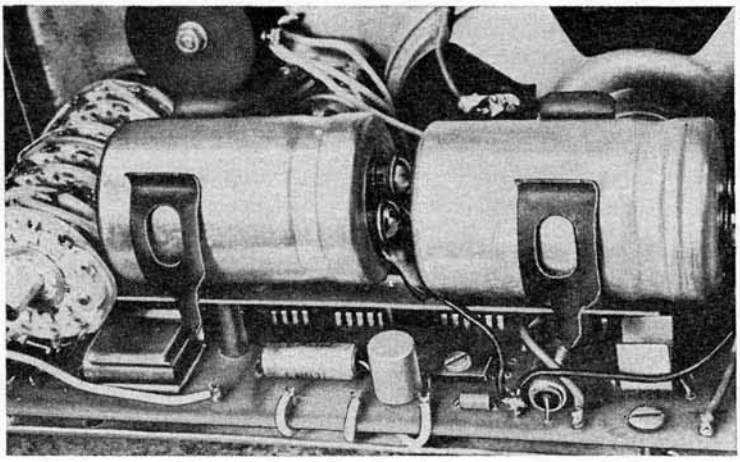


Capacitors C3 and C7 "double-deck" over PC board. With a little care, a compact assembly is possible.



The completed Pitch Reference can be dressed up by using a commercially available dial-plate (see Parts List). The cover should have one or two one-inch holes at the rear to prevent any cabinet resonances.

The two filter capacitors are clip mounted to a short strip of metal secured to the three spacers. Make sure that the end of the capacitor does not short-circuit any of the switch terminals.



ABOUT PITCH

Each octave of a piano scale consists of 12 notes spread out over a 2:1 frequency range. the frequency of the 13th note being precisely twice that of the first. For centuries, musicians have experimented with absolute pitch and the spacing between individual notes. In common use today, however, is the equally tempered, 12-note scale with A4 (the A above middle C) set at 440.0 Hz.

Equal temperament means simply that there is a constant percentage difference in frequency between every two notes. To get twelve notes equally spaced on a percentage basis over a 2:1 frequency spread, each successive note must be $\sqrt[12]{2}$ or roughly 6% higher or lower in pitch than its neighbor. In this way, slight differences in sharps and flats for the various musical keys are averaged out so that twelve different notes per octave can handle virtually any key.

The 6% interval between notes is called a *semitone*, and musicians call 1/100 of a semitone a *cent*. A 1-cent accuracy in frequency is equal to 0.06%.

Since $\sqrt[12]{2}$ is an irrational number, there is no possible way to generate it exactly, and consequently no way to generate a scale precisely. The question is, "How good can we get?" The very best musicians can sometimes spot a ±3-cent cyclic error in pitch, and the very finest tuning forks are only accurate to ±1 cent. They drift a cent or so for every four degrees F of temperature variation.

The Pitch Reference described here is accurate to ±0.5 cent, making it twice as good as the best tuning fork you can buy and six times better than the best musician. Being crystal controlled, it is permanently calibrated and does not age or drift over long periods of time.

Operation. Usually, you will set the Pitch Reference to the same note to which you are tuning the instrument. If the instrument is out of tune, you will hear a distinct low-frequency beat note, perhaps several times a second. Adjust the instrument tuning until the beat note disappears. This is called unison tuning (zero beating). Further adjustment of the instrument will cause detuning in the opposite direction, and a beat note

(*Continued on page* 103)

CB troublespot. Our "live" monitoring confirmed published reports we have received in the past. There were more than twice as many chit-chatters as legal calls, and violators are still gabbing more than ever without call-signs. The FCC flew in a squad of field personnel several months ago to issue citations and impose monetary forfeitures for such violations.

We monitored with a Messenger 300 portable with battery pack from the eighth floor of our hotel. On channel 4, a feminine voice called "Pacifica" dominated the air talking to "Whistling Turtle!" We also heard tidbits such as, "This is the Bogey man, do you read?" and "Calling Candy Cane!" Would you believe every call was originated by a physically mature adult?

We found that channel 6 in the Los Angeles area was used by intelligently speaking adults, but many of them were bootleggers (individuals who purchase transceivers and put them on the air but have never heard of the FCC or part 95).

Only on channel 9 did we discover CB transmissions conducted in orderly fashion. We learned from Fred Berger, KQY0030, that 9 was generally used by the legal operators in the area. Fred, a monitor for Northeast REACT, shed some light on the conditions in Los Angeles and assured us that all was not as discombobulated as it may have sounded on channels 4 and 6.

San Francisco, Calif. This area seemed as much plagued by skip transmissions as Oklahoma City and L.A., but local conditions were not as deranged as other places. Over a three-day period, transmissions were nearly normal, blemished only by a skip caller from the midwest who wanted to know whether Southern California copied "Indiana Top Dog." He received no answer.

Upcoming: Monitour reports from Philadelphia, Penna., New York City, Hartford, Conn., and Boston, Mass.

I'll CB'ing you,

—Matt, KHC2060

PITCH REFERENCE

(*Continued from page 47*)

will occur again, the number of beats increasing the farther out of tune the instrument is made. Beat notes may possibly be caused by ear nonlinearity. You'll get the best results if the sound from both the instrument and the reference go in the same ear.

The Pitch Reference can be used to tune octaves other than the one starting at middle C. For example, any C in the scale can be tuned by using the C4 reference. If sufficient volume is not available, an amplifier and speaker system can be connected to the front-panel output jack.

Variations in pitch can be purposely introduced by changing the crystal in the reference to one that is higher or lower in frequency (sharper or flatter in pitch). This is sometimes desirable in tuning certain older instruments and for tuning the extreme octaves on a piano. —30—

PITCH REFERENCE OUTPUT DATA

NOTE	DIVISION RATIO	APPROXIMATE FREQUENCY (Hz)	STANDARD TRUE FREQUENCY (Hz)
C4	4096	261.6	261.6
C4#	3866	277.2	277.2
D4	3650	293.6	293.7
D4#	3444	311.2	311.1
E4	3250	329.7	329.6
F4	3068	349.3	349.2
F4#	2896	370.0	370.0
G4	2734	392.0	392.0
G4#	2580	415.4	415.3
A4	2436	439.9	440.0
A4#	2298	466.3	466.2
B4	2170	493.8	493.9