Electronics and Music

Part XIII Stroboconn, precise frequency meter, measures sound accurately to hundredths of a semitone

By

RICHARD H. DORF*

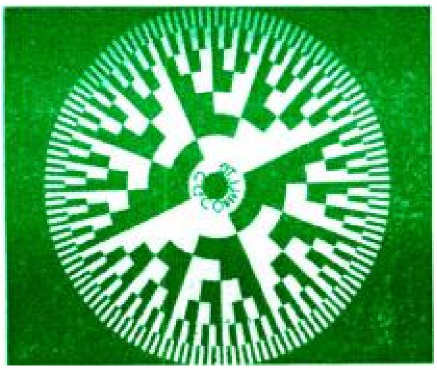

Photo A—Discs used in Stroboconn.

WHILE this series is concerned with electronic musical instruments, the *Stroboconn*[1] is so closely allied with electronic music and so useful with electronic organs as well as more conventional acoustic instruments that it should be of great interest to all who work with both electronics and music.

The Stroboconn is in essence an extremely accurate frequency meter. It was specifically designed as an aid in tuning musical instruments, by the manufacturer of the Connsonata—an electronic instrument we shall describe later in the series. It is also highly effective in the laboratory and in industry for measuring vibrations, oscillations, and other periodic phenomena within its frequency range.

The instrument is in effect a superstroboscope. Twelve discs, each a replica of the one shown in Photo A, revolve at different speeds. Each disc corresponds to a note of the tempered musical scale and revolves faster than the preceding lower one by a ratio of almost exactly the 12th root of 2. A special large neon lamp is excited by a microphone-fed amplifier. When the microphone is placed near a source of sound—a piano tone, for example, or an organ note—the neon lamp flashes at the frequency of the sound, illuminating the discs stroboscopically. If the speed of one of the discs is such that the number of black segments passing a given point per second is the same as the audio frequency being measured, the pattern appears to stand still. Calibrations on the Stroboconn then indicate the frequency. All 12 discs can be seen through small windows, as Photo B shows.

Photo C is a photograph of one of the windows, exposing a segment of the disc behind it in motion. As Photo A indicates, each disc has seven concentric rings of patterns, each ring having twice the number of black portions as the adjacent inner one. Thus each disc takes care of the same note in seven succeeding octaves. In Photo C the narrow part of the window exposes the innermost ring on the disc. The first three rings are invisible because the frequency being measured corresponds to that of the fourth ring, in which the stopped pattern can be seen. This tone apparently has some harmonic structure, for the fifth and sixth rings are also stopped, though they are illuminated less well.

Electronic circuitry

The most essential requirement for accuracy in an instrument of this kind is that the motor driving the discs run at constant speed. In the Stroboconn this regulation is provided by driving the motor with a tuning-fork-excited amplifier, diagrammed in Fig. 1. The tuning fork is made of a special alloy, called Connivar, which has an extremely low temperature coefficient. The metal is so stable that the accuracy of the fork varies only a maximum of .002 percent per degree Centigrade. For musical purposes a pitch accuracy of

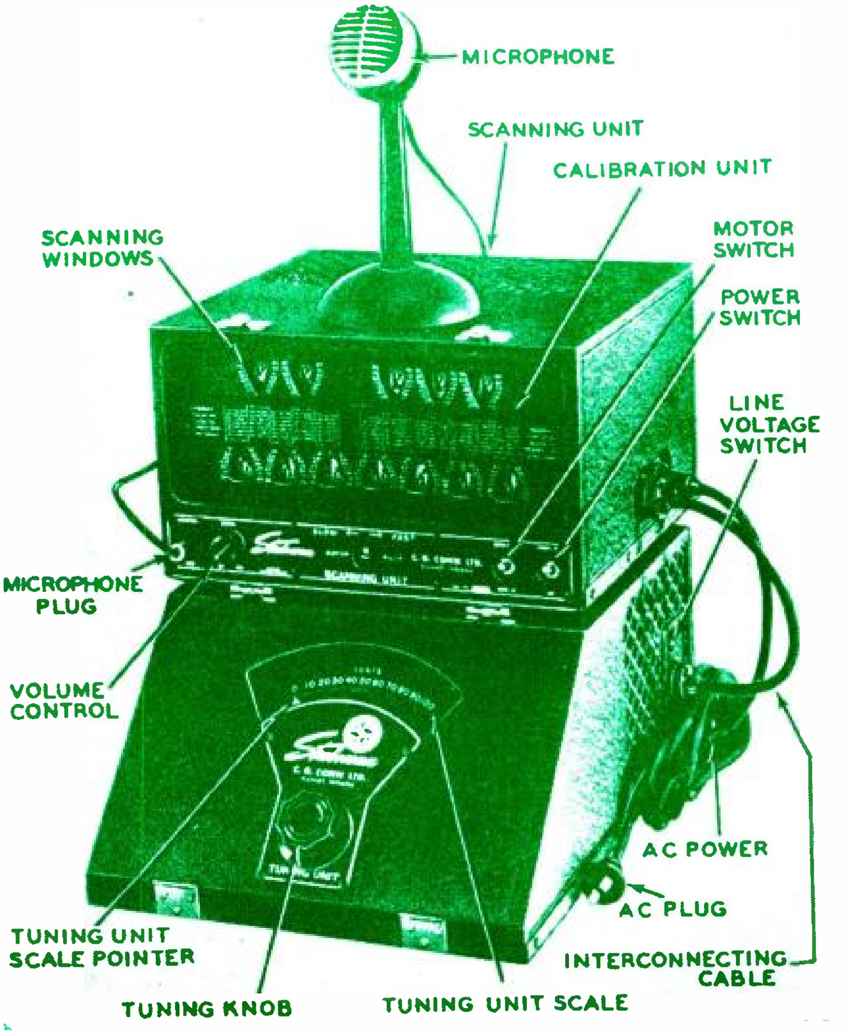

Photo B—The Stroboconn is in two sections. In use they are removed from covers and the scanning unit placed atop the tuning unit. Either an air or contact microphone may be employed, being placed near source of sound.

---

*Audio Consultant, New York

0.1 percent is considered very high and few people (if any) can perceive pitch variations so small. In continuous operation the entire instrument, including gears, fork, and all other variants, is accurate to within .05 percent.

The fork is driven by a regenerative circuit, in which respect it resembles electronic oscillators. The pickup coil (Fig. 1) drives the first grid of a 6SC7. The plate output is fed to the grid of the second section, part of whose plate load is the fork drive coils. Thus the output of the fork is fed back in the correct phase to furnish driving signal, the driving power being supplied by the B-voltage source, a standard rectifier-filter combination.

The fork-controlled signal is then fed through a 6SN7-GT phase inverter to a push-pull-parallel 6V6-GT output stage. The secondary of the output transformer drives the synchronous disc motor.

The normal frequency of the tuning-fork oscillator is 55 cycles, but the frequency can be varied at will. Photo D shows the fork and the sliding weights whose position can be changed to vary resonant frequency. The varying mechanism is operated by a knob which appears at the bottom of the lower unit in Photo B.

The upper of the two units in which the Stroboconn is mounted contains the motor, discs, and flashing amplifier, diagrammed in Fig. 2. The amplifier is entirely conventional: a voltage amplifier, phase inverter, and push-pull output stage. A special, large, U-shaped neon lamp is fed by the secondary of the output transformer. The lamp is large enough to provide light behind all the discs, which are translucent.

The power connections in Figs. 1 and 2 are rather confusing. The scheme is shown better in Fig. 3, an extract from the other two diagrams. Two power switches are supplied. One, called the POWER SWITCH, is in series with one side of the 117-volt a.c. line and a protective fuse. The other, the MOTOR-RUN WARM-UP switch, is a double-pole, double-throw unit. In the warm-up position in which it appears in Fig. 3 (and with the power switch closed) 117-volt, 60-cycle power is fed to the motor and the output of the tuning-fork amplifier is dummy-loaded by a 500-ohm, 50-watt resistor. After the motor and fork have warmed, the switch is thrown to the run position in which the motor is connected to the fork amplifier and the flashing amplifier power transformer is energized. After the flashing amplifier has warmed up, the instrument is ready for use.

The discs are run by the motor through a system of gears. Since the 12th root of 2 is not a rational number—it can be carried to an infinite number of decimal places—the gear ratio from one disc to the next is not quite correct; no one has yet been able to design gears with a nonintegral number of teeth! It is so close to correct, however, that the difference is not perceptible.

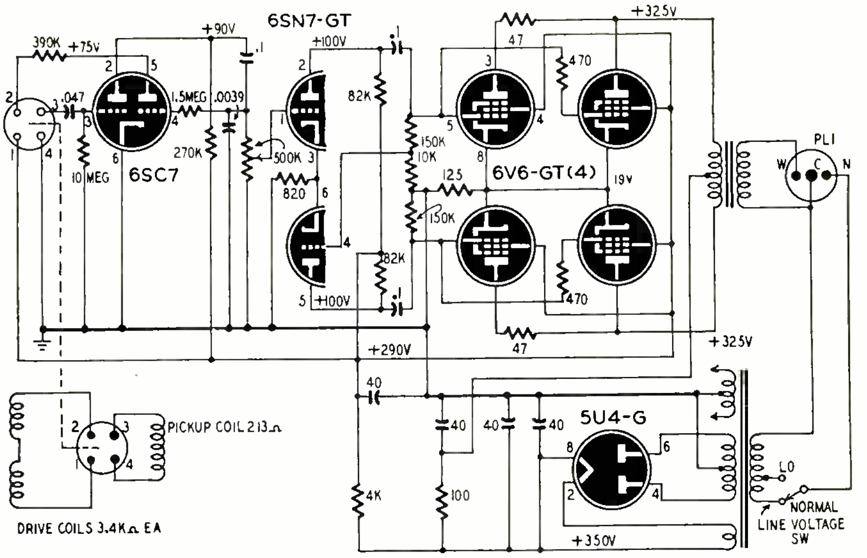

Fig. 1—The motor of the Stroboconn is driven by this tuning-fork-controlled amplifier. The fork is made of Connivar, has very small temperature co-efficient.

Reading frequency

The normal position for the tuning unit control is at zero. The tuning fork weights are then set so that the oscillation frequency for the synchronous motor is 55 cycles per second. The motor is so geared to the discs that the A disc rotates at 27.5 revolutions per second. The first (inner) ring has two black portions so that a black portion appears in a given position 2 times 27.5, or 55 times, per second. The fourth ring has 16 black portions; thus one appears 16 times 27.5, or 440 times, per second. If the signal fed into the microphone is at 440 cycles, the lamp will flash once each time that a black mark appears in the fourth ring and the marks will appear to stand still. At 440 flashes per second, however, each black mark of the first ring is illuminated 8 times each time it appears, so it does not stand still. As a result the fundamental frequency of whatever tone is being measured is indicated by the innermost stopped pattern. Octave harmonics of the tone are indicated by the stopping of additional rings toward the outer edge of the disc (or the wide portion of the window).

Each ring of each disc is numbered around the windows in accordance with the ordinal number of the note. The calibration strip between the two sets of windows indicates the exact frequency of each note, based on an A of 440 cycles. That calibration is not necessary, of course, for routine instrument tuning, but is helpful for other purposes.

Interpolation

Probably the feature most responsible for the Stroboconn's versatility in both music and nonmusic applications is the ingenious provision made for reading with great accuracy any frequency within its range. The basis of this is the knob-controlled, calibrated sliding

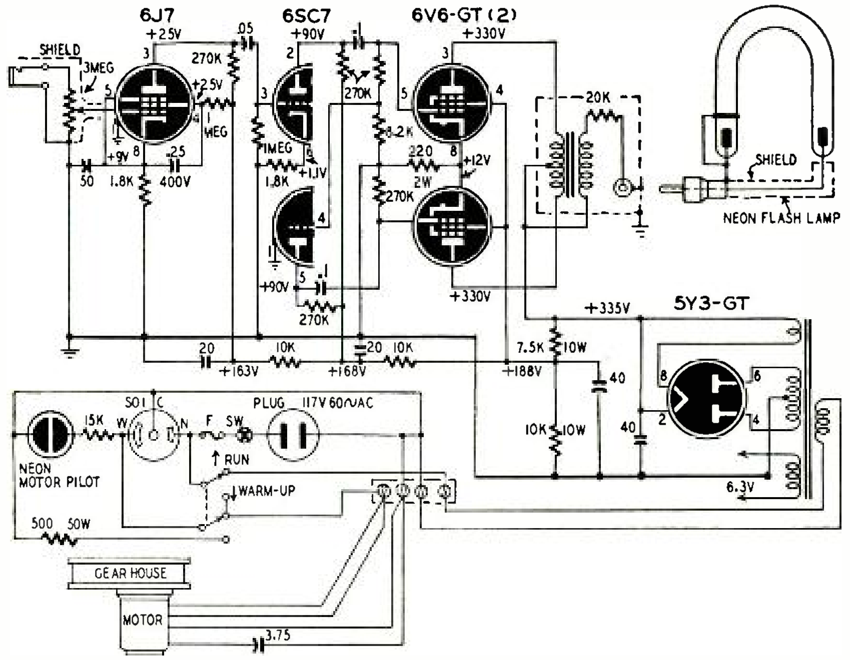

Fig. 2—Diagram of the scanning unit. The neon flash lamp is of special design.

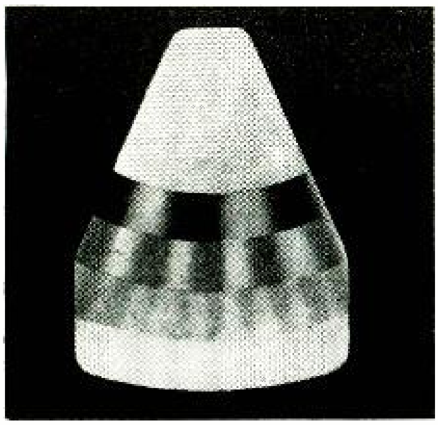

Photo C—Photo of a scanning disc in operation shows stroboscope patterns.

weight on the tuning fork. Referring again to Photo B, as the tuning unit knob is rotated the pointer on the scale above it reads the frequency change in terms of hundredths of a semitone. These small intervals are known as *cents*. Since the musical scale is built on a logarithmic, not an arithmetic, basis, a cent represents a constant *percentage* change in frequency rather than a constant numerical change. A semitone or halftone (the interval between, say, C and C♯ or E and F) represents a frequency ratio between the two pitches of the 12th root of 2 (see August, 1950, issue). One cent therefore represents a ratio of

$$\sqrt[12]{2}/100$$

which works out to approximately .058%. As an example, a 1-cent increase in the frequency of A-440 is 440 × 1.00058, or 440.25 cycles.

In practical terms the meaning of the above is quite simple. If the middle A is sounded on a piano or organ being tuned with the Stroboconn, ring No. 57 should stand still. Suppose it rotates very slowly to the right, indicating the tone is sharp, then to tune it to exact pitch the tuner adjusts the musical instrument until the pattern stands still. Or, to find out just how sharp it is, he rotates the tuning unit control upward from zero until the pattern stands still. If the pointer is then at 1 cent, he knows it is 0.25 cycle sharp.

Tuners rarely need to know how sharp or flat a tone is except for the "stretching" techniques described below. Of greater value is the fact that any frequency of an oscillator, or vibration, or anything else in laboratory or industry may be measured in this way. A book of tables is furnished with the Stroboconn. With its aid the operator can discover the exact frequency (to five significant figures) of anything that can be either fed to the flashing amplifier or picked up by the microphone. He merely manipulates the tuning knob until one of the patterns is stationary, then refers to the tables for the frequency.

Piano tuning

The old-time piano tuner was usually a craftsman of great skill and years of experience. Many of the best of them started their careers in piano factories, working up by stages to the exacting job of adjusting new pianos before they were shipped. Expert tuning has always required an intimate knowledge of piano construction, a first-class ear for pitch, and much practical experience.

One of the reasons that tuning has never been a purely mechanical job is that an expert tuner does not actually tune the piano notes to theoretically correct pitch, except in the middle octaves. The overtones of a struck string are not true harmonics of the fundamental but are instead slightly sharper—higher in pitch—than the true harmonics would be. If the entire piano is tuned to exact pitch, the upper overtones of the middle octaves are sharper than the corresponding fundamentals of the upper octaves. Too, the upper harmonics of the lower octaves are sharper than the corresponding fundamentals of the middle octaves. The result is, as any musician who has ever heard a piano so tuned will instantly say, that it does not "sound right."

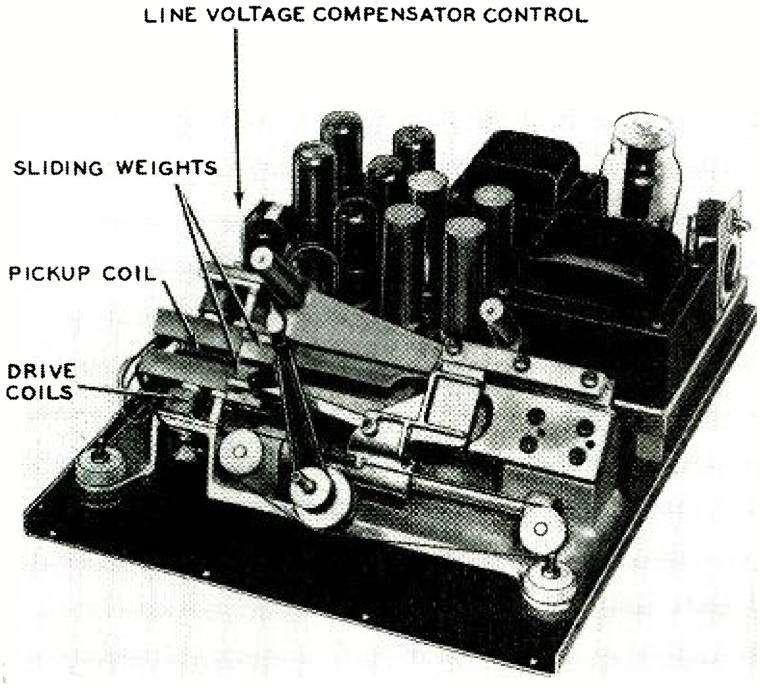

Photo D—The tuning unit. The tuning control slides weights on fork.

To make it sound more natural, the tuner "stretches." He tunes the upper octaves sharp and the bass ones flat. Most tuners, aware of the fallacy of tuning an entire instrument to true pitch, balk at the idea of using an electromechanical device.

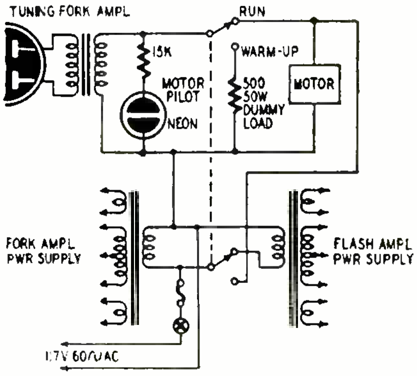

Fig. 3—The motor start circuit redrawn.

However, the variable, calibrated pitch adjustments of the Stroboconn overcome the difficulty. After a little experiment, a tuner determines just how sharp or flat each note of these "stretched" octaves should be tuned to suit his and his clients' tastes and he notes the pitch change in cents. In future tunings, he needs merely to shift the tuning knob according to his notes and tune for a stopped pattern. The time saved and the accuracy gained are well worth while. The accuracy is especially valuable when two pianos, to be used in duo-piano playing, are tuned, for then it is essential that they correspond. For tuning the lower octaves it is not even necessary to experiment and make notes. The tuner simply adjusts the piano so that with the pointer on zero cents, the higher overtones of the bass notes, which appear in rings outside that of the fundamental, give stopped patterns. In this way, he is actually tuning the overtones of the notes to true pitch, not the fundamentals, which will automatically be slightly (and desirably) flat.

In next month's article we shall begin our discussion of tone coloring in electronic instruments. Following that article on this important phase of electronic music we shall present a detailed description of the Hammond organ.

—end—

---

[1] C. G. Conn, Ltd., Elkhart, Ind.