

Electronics and Music

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

By

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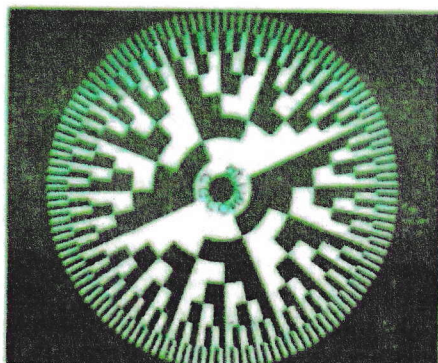


Photo A—Discs used in Stroboconn.

WHILE this series is concerned with electronic musical instruments, the *Stroboconn* 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 super-stroboscope. 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

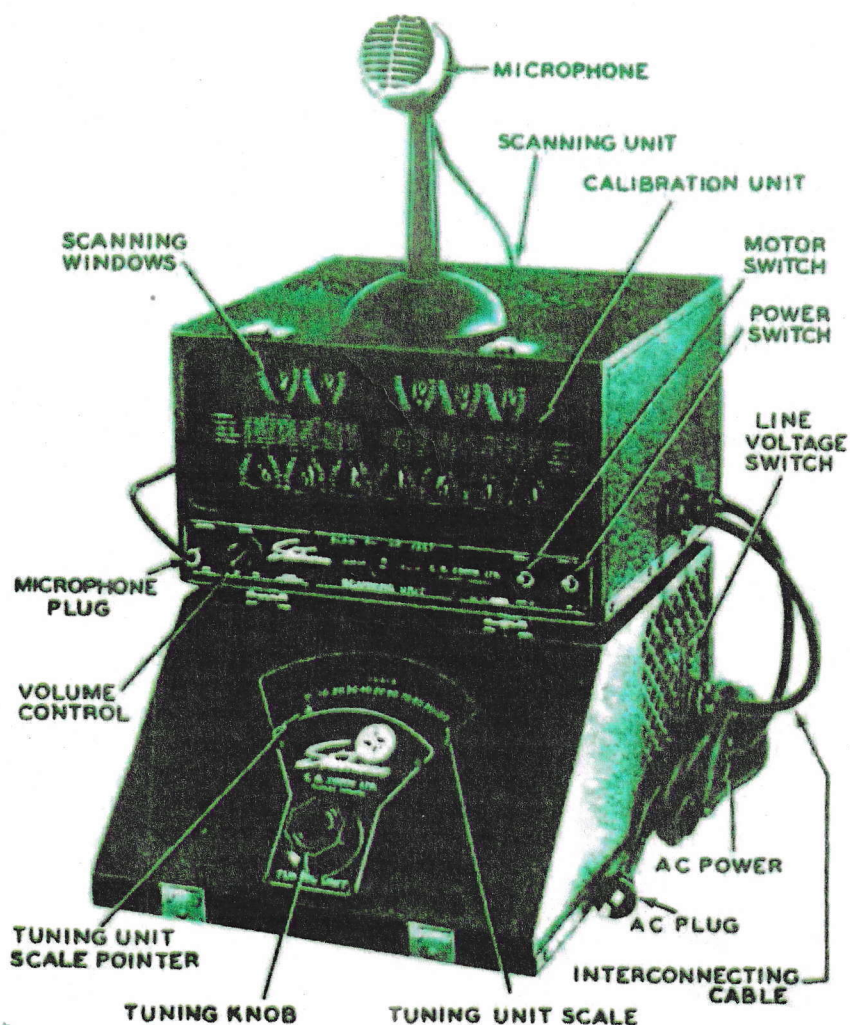


Photo B—The *Stroboconn* is in two sections. In use they are removed from covers and the scanning unit placed atop the tuning unit. Either an air or contact microphone may be employed, being placed near source of sound.

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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.

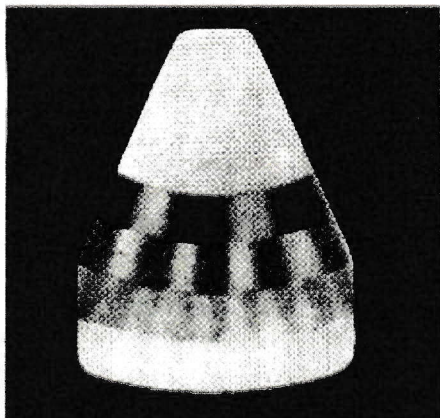


Photo C—Photo of a scanning disc in operation shows stroboscope patterns.

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 half-tone (the interval between, say, C and C \sharp 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

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

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 Strobocoenn, 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 Strobocoenn. 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."

To make it sound more natural, the tuner "stretches." He tunes the upper

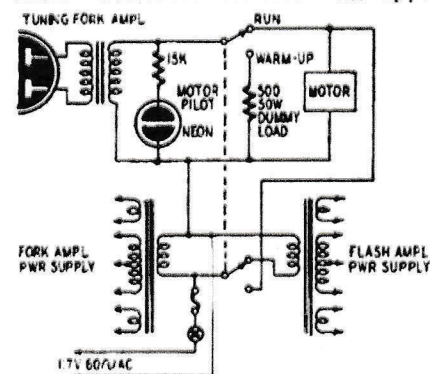


Fig. 3—The motor start circuit redrawn.

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.

However, the variable, calibrated pitch adjustments of the Strobocoenn 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.

J. C. G. Conn, Ltd., Elkhart, Ind.

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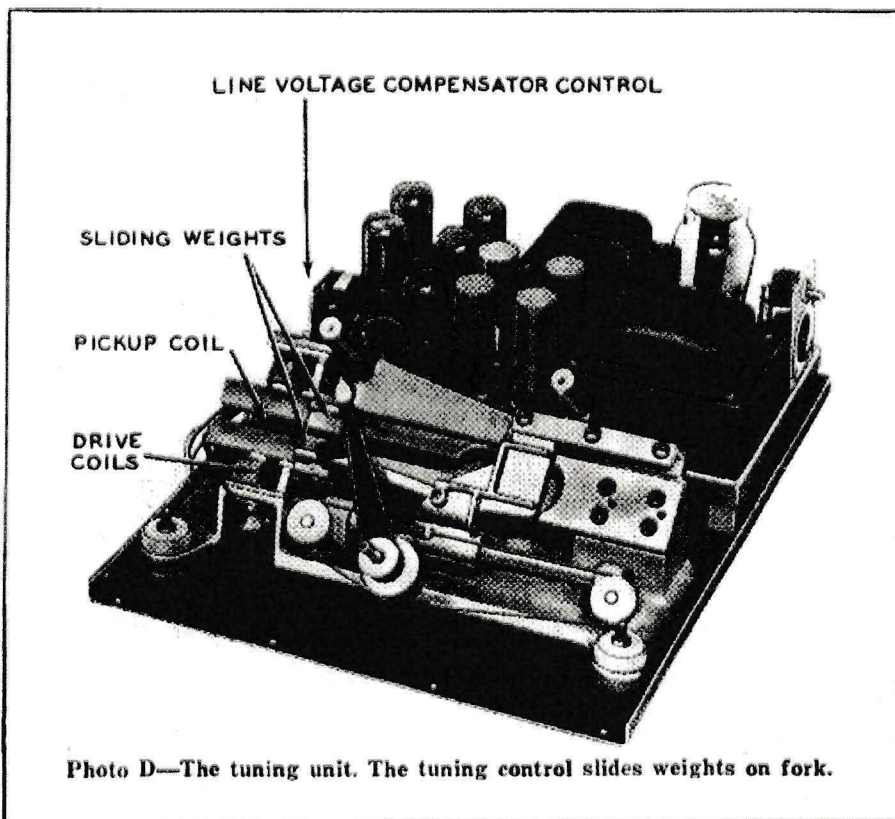


Photo D—The tuning unit. The tuning control slides weights on fork.