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ELECTRICAL COMMUNICATIONS TECHNIQUE
AND ITS APPLICATIONS IN ALLIED FIELDS

AN IMPROVED AUDIO OSCILLATOR

FOR a number of years the General Radio Type 213 Audio Oscillator has served in many laboratories as a tone source for bridge measurements and other purposes. This oscillator, which consists of a single-button microphone-driven tuning fork, has been widely used because of its simplicity, compactness, low cost, and ease of operation.

A redesign of this instrument, resulting in the Type 813 Audio Oscillator, has produced very definite improvements along the following lines: (1) more accurate calibration to any specified frequency value, (2) lower damping and greater frequency stability, (3) complete independence of output and fork driving circuits, (4) more reliable operation and self-starting characteristics, (5) much lower harmonic content in output, (6) fork enclosed and free from damage and dirt, (7) provision made for a small self-contained 4½-volt dry battery for intermittent operation; or, alternately, outside batteries for continuous service or greater power output, (8) a reduction of the sound in air produced by the oscillator.

These improvements have been accomplished by the use of a much more massive fork of unique design, by employing two microphones of an improved type symmetrically loading each tine, and by the use of an output filter which reduces the harmonics in the output.

The fork is cut from a rectangular bar of uniform cold rolled steel which is then cadmium plated to resist corrosion. Two rigid back microphones are mounted from the heel of the fork

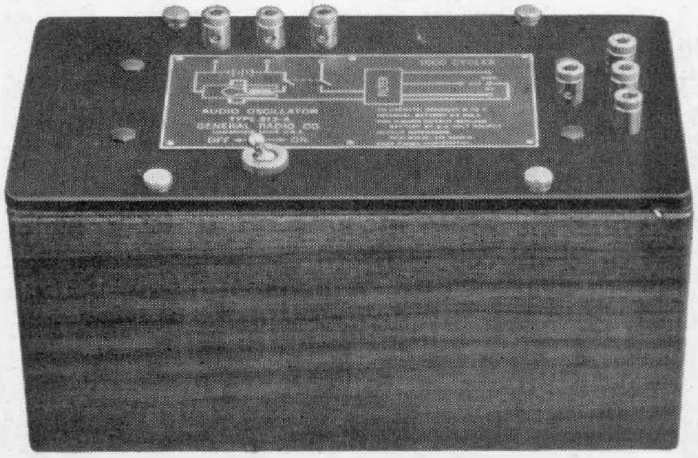


Figure 1. External view of 1000-cycle Type 813-A Oscillator

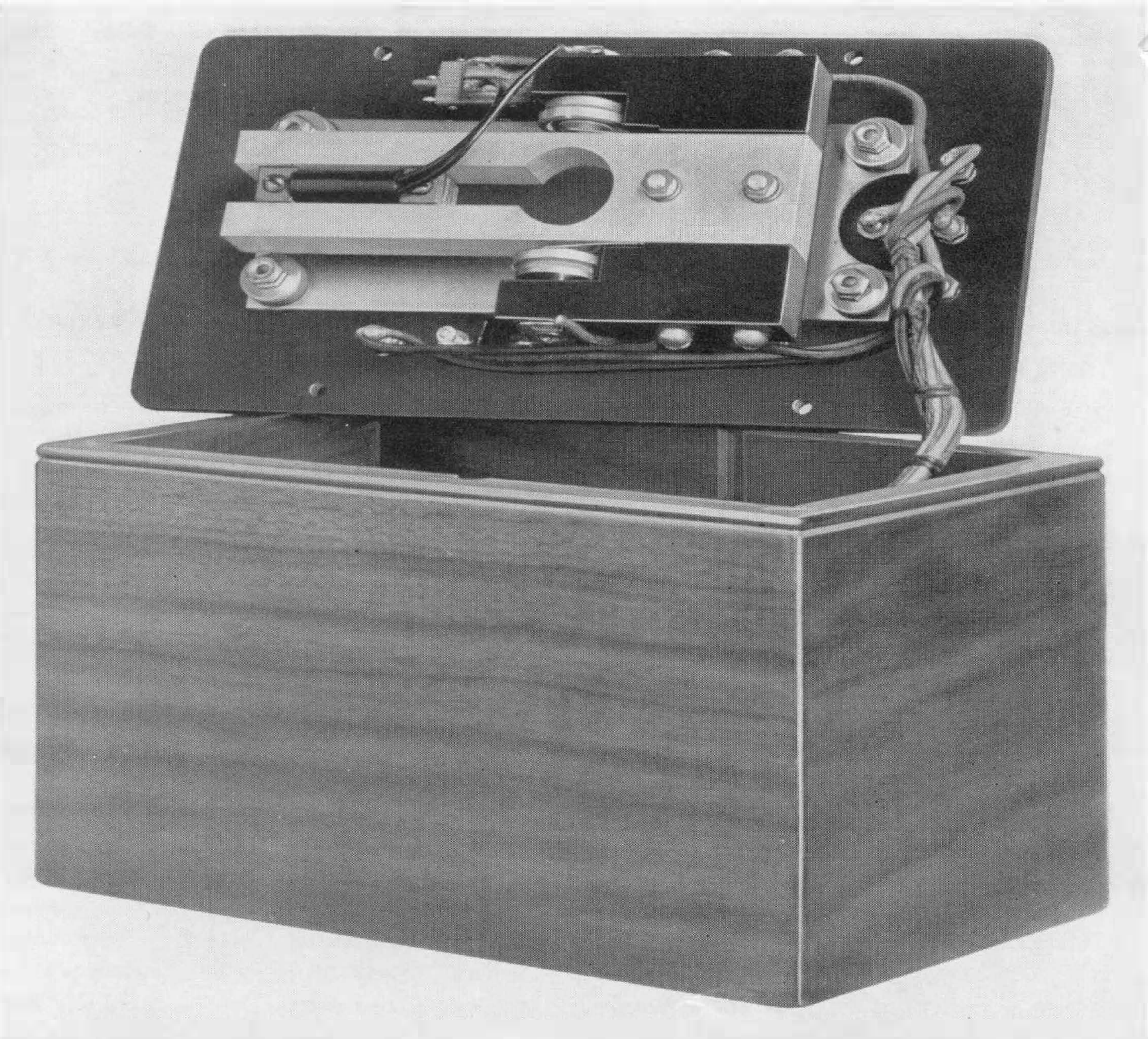


FIGURE 2. Internal view of 400-cycle oscillator, showing fork and method of mounting

and are located symmetrically on the tines at, or back of, the point where maximum flexure occurs. In this manner, the free vibration of the fork is influenced only to a very slight degree by the load of the microphones.

The fork is mounted rigidly at the heel above a small metallic base panel which carries the driving electromagnet located between the tines. The base panel is suspended internally with four resilient mountings beneath a bakelite panel, which carries the terminal posts and control switch and which serves as a cover for the walnut cabinet.

Since the output of the microphone button contains harmonics of considerable amplitude, a filter is provided to obtain good waveform. This filter attenuates the second harmonic by more than 40 decibels.

The wiring diagram (Figure 3) shows how one microphone, in series with the electromagnet and whatever battery is connected across the terminals *A* and *B*, drives the fork. The other microphone, in series with the filter and whatever battery is connected across the terminals *A* and *C*, independently supplies the electrical output of the oscillator. The switch controls both circuits simultaneously.

Output impedances of 50, 500, and 5000 ohms are provided. Four output terminals are so arranged that the Type 274-M Double Plug may be quickly attached to give any one of these three internal impedance values. The output circuit is completely isolated from the driving circuit, and there is no direct-current component in the output.

For intermittent operation with a moderate power output, an internal 4½-volt battery is connected across the terminals *A* and *B* and the terminal *C* is connected, externally, to the terminal *B*. The single battery thus energizes both the driving- and the output-microphone circuits. For greater output, or for continuous operation over extended periods, the internal battery may be replaced by an external battery of greater capacity or by some other low impedance direct-current source of 4½ volts to 8 volts, connected externally across the terminals *A* and *B*, with *C* joined to *B*.

The best frequency stability and the lowest harmonic content are obtained when the amplitude of fork vibration is small, corresponding to a driving battery voltage not greater than 4½ volts. Maximum power output consistent with these conditions is obtained with a total output battery voltage of 6 to 8 volts.

The operating characteristics of the Type 813 Oscillator are given below.

Frequency: The Type 813 Audio Oscillator is available in two models, 400 cycles and 1000 cycles. Other frequencies between 300 cycles and 1500 cycles can be obtained on special order.

The frequency is adjusted to within 0.5% of the specified value. The temperature coefficient is −0.007% per degree Fahrenheit and the change in frequency with driving voltage is less than 0.01% per volt. The frequency is entirely independent of load impedance.

Waveform: The total harmonic content of the output into a matched resistive load is less than 0.5% with

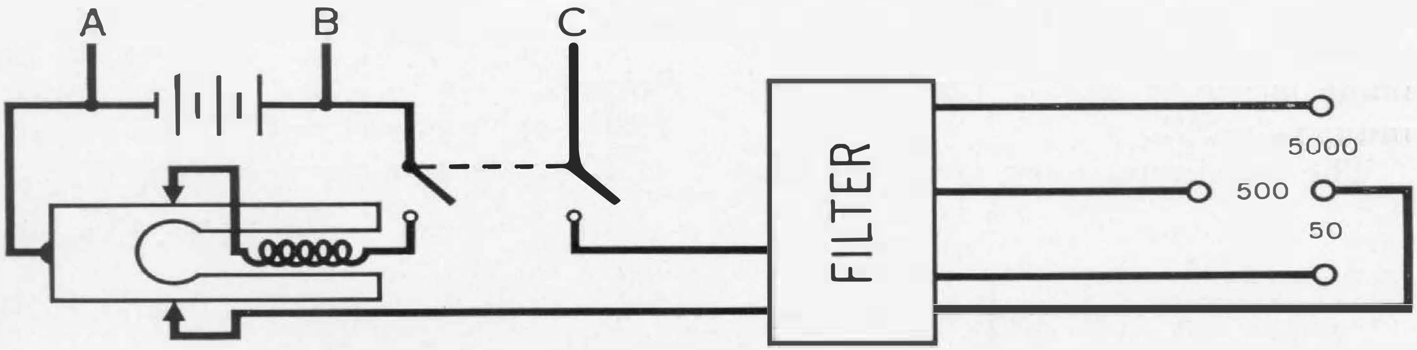


Figure 3. Circuit diagram of Type 813-A Oscillator

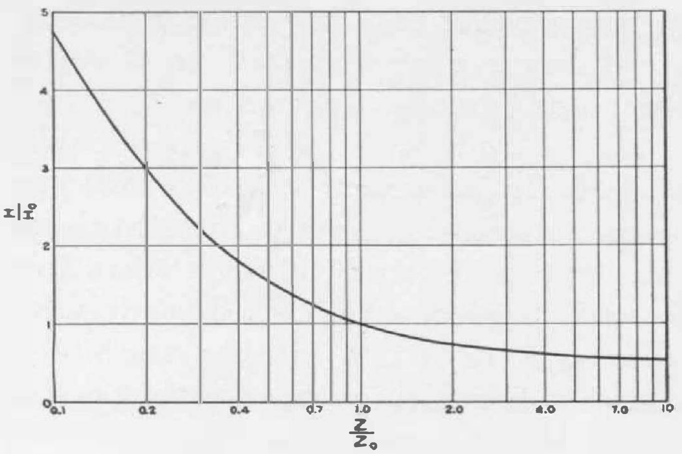


FIGURE 4 (left). Variation in harmonic content of output voltage as a function of the ratio of the load impedance, Z, to the matched load impedance Z_0. Note that the harmonic content is extremely small for high impedance loads. This makes it possible to work the oscillator into the grid circuit of a vacuum-tube amplifier to obtain higher power output with good waveform

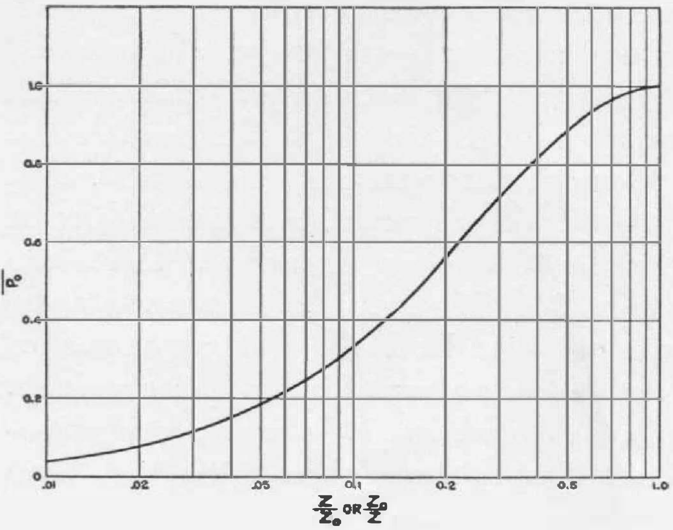


FIGURE 5 (right). Ratio of power output, P, to the maximum power output, P_0, as a function of output impedance. The horizontal scale may be read as $\frac{Z}{Z_0}$ or $\frac{Z_0}{Z}$, depending upon whether the load impedance is larger or smaller than the matched value, Z_0

4½-volt drive and less than 0.8% with 6-volt drive. Figure 4 shows how the ratio of total harmonic content, H, to the harmonic content, H_0, with a matched load, varies with the ratio of load impedance, Z, to matched load impedance, Z_0.

Output: The output to a matched load impedance is 20 to 30 milliwatts with 6-volt drive and 10 to 15 milliwatts with 4½-volt drive. Figure 5 shows how the ratio of output power, P, to the maximum output power, P_0, decreases as the load impedance, Z, is made larger or smaller than the optimum value, Z_0.

The maximum open circuit output voltage is 20 to 24 volts with 6-volt drive and 14 to 17 volts with 4½-volt drive.

Input Power: The driving microphone draws about 25 milliamperes at 4½ volts and 30 milliamperes at 6 volts. The output microphone draws about 60 milliamperes at 4½ volts and 80 milliamperes at 6 volts. These values are subject to considerable variation.

Dimensions: Both models, (length) 9 x (width) 5 x (height) 6 inches, overall.

Price:

1000-cycle model —	$34.00
400-cycle model —	36.00

— H. W. LAMSON

THE ANALYSIS OF COMPLEX SOUNDS OF CONSTANT PITCH

ONE of the many uses of the TYPE 636-A Wave Analyzer is in the frequency analysis of sounds which have a constant pitch. The selectivity and ease of operation of the analyzer make it particularly useful for applications of this sort.

An excellent example of this type of problem is the analysis of the tone produced by an automobile horn. Necessary equipment consists of a suitable microphone, an audio-frequency amplifier, and the wave analyzer, and should be arranged as shown in Figure 1. The microphone should have a reasonably good response over the range up to 10,000 cycles. In the analysis described here, a low-priced piezo-electric microphone was used. The amplifier is used to obtain a voltage of sufficient magnitude to operate the wave analyzer and should, of course, have a flat response over the frequency range in which measurements are to be made.

Three different automobile horns were analyzed with this equipment and the results are shown in Figures 2, 3, and 4. The scale of ordinates, *Sound Pressure in Percentage of Fundamental*, is proportional to the wave analyzer readings, since all elements in the system have essentially flat frequency response curves.

The horn in Figure 2 is a type used on low-priced automobiles and has a loud, piercing tone. An examination of its spectrum shows a resonance in the region of the tenth harmonic, which is nearly thirty times as strong as the fundamental. This accounts for the peculiar tone quality of this type of horn. The horns shown in Figures 3 and 4 are a pair which are intended to be sounded at the same time. Each has a rather pleasant tone, not greatly different from that of some musical instruments. The output of each horn contains harmonics of approximately equal amplitudes over a wide frequency range with no pronounced resonances.

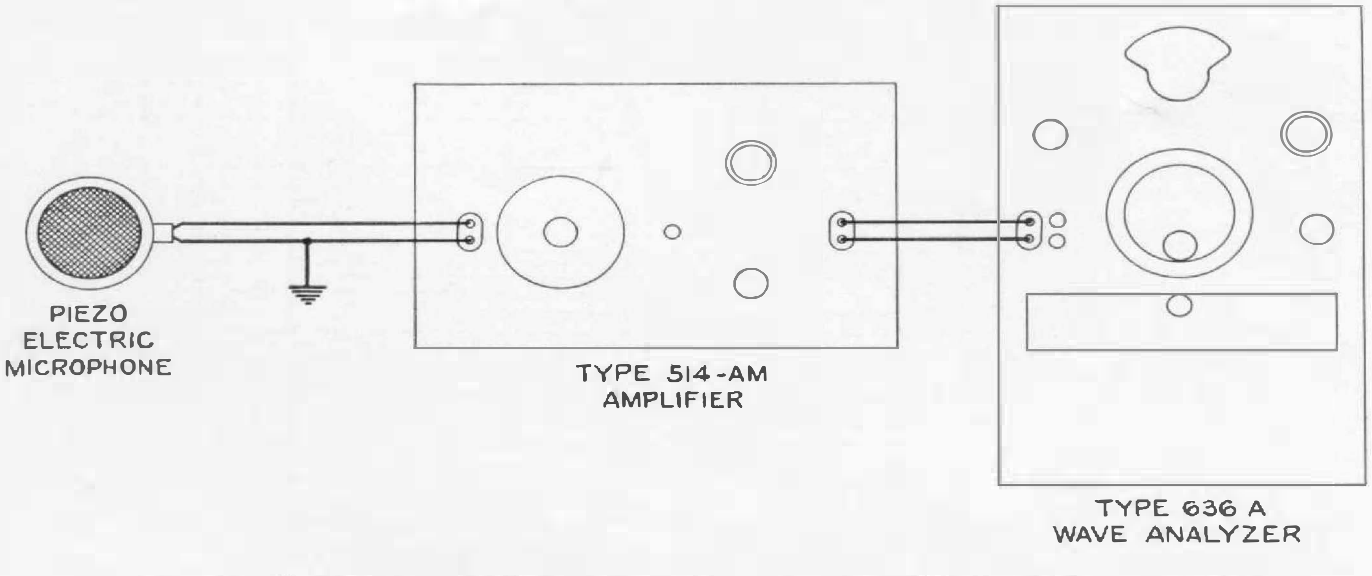


FIGURE 1. Arrangement of equipment for analyzing sounds of constant pitch

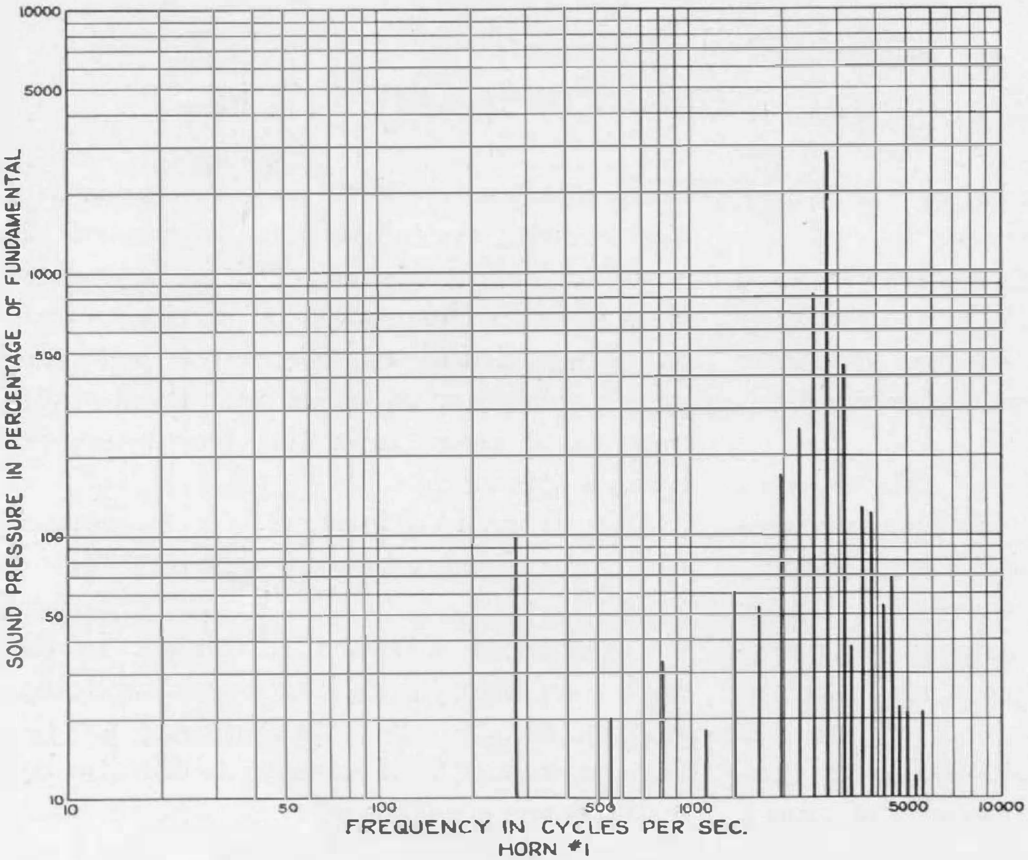
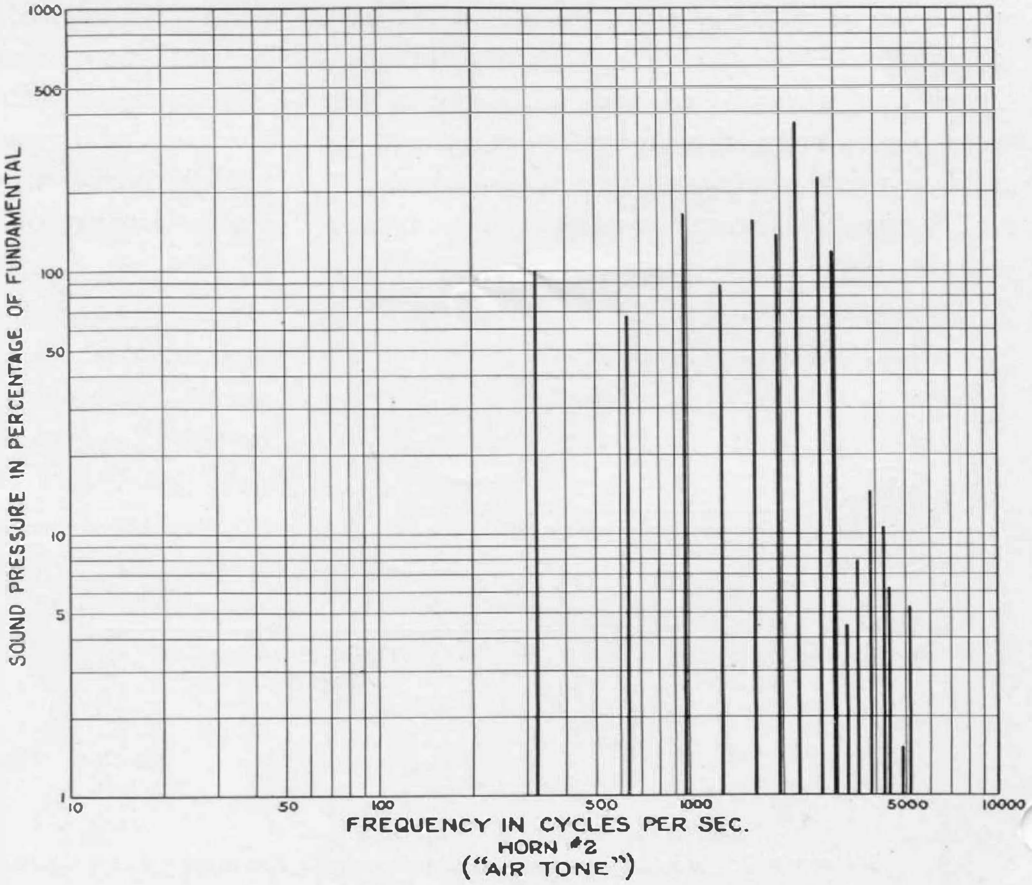


FIGURE 2 (above). Frequency spectrum of Horn No. 1
FIGURE 3 (below). Frequency spectrum of Horn No. 2



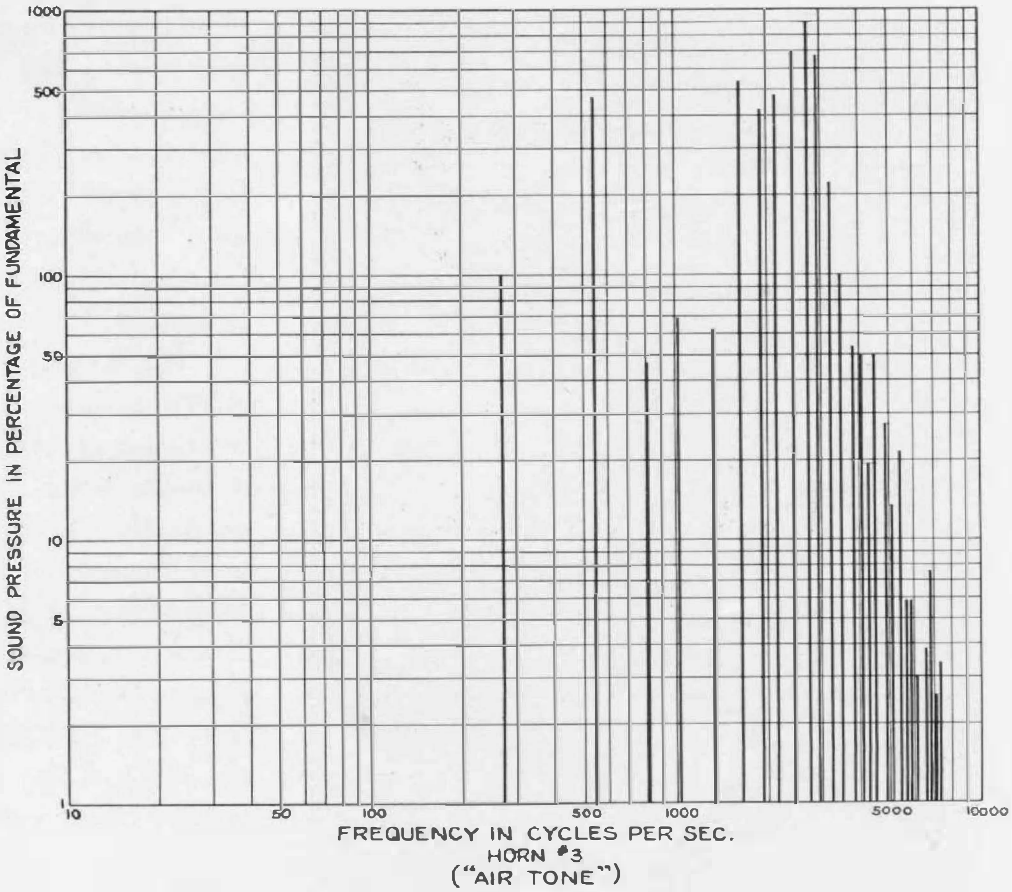


FIGURE 4. Frequency spectrum of Horn No. 3

A visual indication of the waveform, made by means of a cathode-ray oscillograph and sweep circuit, is often useful in interpreting the frequency analysis. A permanent record can be made by photographing the oscillograph pattern with a still-picture camera. The necessary equipment is shown in Figure 5 and consists of the piezo-electric microphone, an amplifier, a cathode-ray oscillograph with linear sweep circuit, and a hand camera.

To obtain sufficient deflecting voltage for the oscillograph, an amplifier with a high voltage output, such as the new General Radio TYPE 714-A Amplifier, is needed. The oscillograph (TYPE 687-A) has a self-contained sweep circuit and power supply. For making the photographs of Figure 6, a camera having an f/4.5 lens was used with Verichrome film. The exposure was 0.2 second.

The three oscillograms of Figure 6

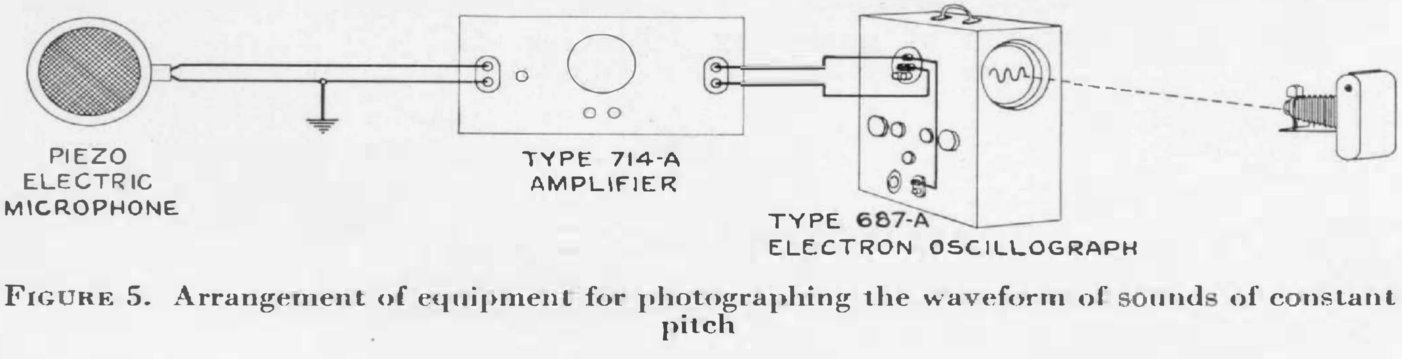


FIGURE 5. Arrangement of equipment for photographing the waveform of sounds of constant pitch

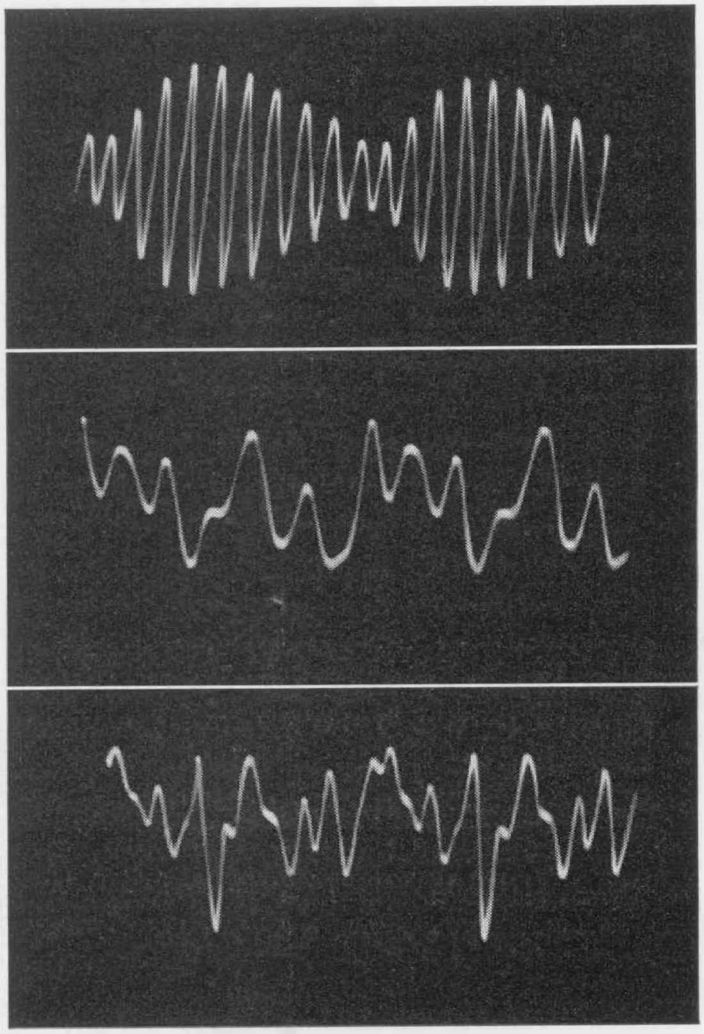


FIGURE 6. Oscillograms showing waveform of horns (top) No. 1, (center) No. 2, (bottom) No. 3

are, respectively, the waveforms of the horns of Figures 2, 3, and 4. In each oscillogram the sweeping frequency was equal to one-half the horn fundamental frequency. Note that Figure 6 shows that the fundamental of the horn of Figure 2 appears as a modulation of the tenth harmonic.

These same methods of analyzing and photographing sounds of constant pitch can, of course, be applied to a large number of problems. The noises of internal combustion engines, mufflers, and various types of electrical and mechanical equipment can be treated in the same manner as the horn tones. A harmonic analysis of a sound of this type will readily show up the frequencies at which resonant phenomena are taking place. In the case of a horn tone, proper treatment of the acoustic systems producing resonances will improve the quality of the sound. In other applications where it is desired to reduce the intensity or disagreeableness of a sound, as in a muffler, for instance, the resonances may be shifted, by proper design, to points where their effect is less noticeable.

— H. H. SCOTT

The General Radio equipment mentioned in the foregoing article is all standard catalog apparatus. The prices are as follows:

TYPE 636-A Wave Analyzer . . .	$490.00
TYPE 514-AM Amplifier	85.00
TYPE 714-A Amplifier	190.00
TYPE 687-A Electron Oscillograph	184.00

The microphone used for this particular work was an Astatic Type D104, which lists at $22.50. This microphone can be obtained from the General Radio Company or from the manufacturer.

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