Alexander Graham Bell, Joseph Henry, and the “empty helix” experiment

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Alexander Graham Bell visits Joseph Henry
March 1-2, 1875

Joseph Henry (1797 – 1878)

– First Secretary of Smithsonian (1846 – 1878); Previously a Professor at Princeton College; Early contributor to science of electromagnetism. Contemporary of Ohm, Faraday, and Ampere – electrical units are named after these individuals.

Alexander Bell (1847 – 1922)

– Teacher of the deaf; Professor of Vocal Physiology at Boston University. In 1875, he is figuring out how to send many telegraph messages on a single wire. His work follows the 1872 invention of the duplex telegraph of Stearns.
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Dear Mama and Papa, (letter of March 18, 1875) …

When I related a experiment that at first sight seems unimportant—was startled at the sudden interest manifested. I told him that on passing an intermittent current of electricity through an empty helix of insulated copper wires a noise could be heard proceeding from the coil—similar to that heard from the telephone. He started up and said, Is that so? Will you allow me Mr. Bell to repeat your experiments.
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The “telephone” mentioned is a telegraphic device using tuned reeds

Make and Break transmitter (at the vibration frequency of the iron reed)
And matched receiver with a second iron reed resonantly excited by pulses
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I sat the instrument working and he sat at a table for a long time with
the empty coil of wire against his ear
listening to the sound.

I felt so much encouraged by his
interest that I determined to ask
his advice about the apparatus I have
designed for the transmission of
the human voice by telegraph. I explained
the idea — I said that you advise
me to do — publish it and let other
work it out — or attempt to solve the
problem myself. He said he thought it was "the germ
of a great invention" and advised me
to work at it myself instead of publishing.
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I said that I recognized the fact that there were mechanical difficulties in the way that rendered the plan impracticable at the present time. I added that I felt that I had not the electrical knowledge necessary to add to overcome the difficulties. His laconic answer was "Get it!"

I cannot tell how much these two words have encouraged me.
Why does this work?

Ampere’s observation that parallel wire with current in same direction attract

Therefore when current is flowing in an empty helix, it contracts axially.

When current is pulsing, the empty helix pulses axially producing sound.
What do we know about actual helix?

In an earlier letter (Thanksgiving 1874) Bell describes the first observation of this effect – the coil consisted of No. 23 (AWG) insulated wire having a resistance of 12 ohms. It was excited with a pulse frequency of 100 pulses per second.

Therefore when current is flowing in an empty helix, it contracts axially.

When current is pulsing, the empty helix pulses axially producing sound.
We repeated the experiment and it works well

= sound at pulsing frequency

= sound at twice the frequency

It works even better using a flat helix of 100 turns of heavier gauge wire (20 AWG) at higher frequencies (1000 Hz).
Summary

Bell and Henry meet in March 1875 – Bell is Telegraph Experimenter and Henry is Scientist and Smithsonian Director

Bell demonstrates empty coil experiments to Henry

**empty coil produces sound when excited by pulsed current**

We replicated Bell’s experiment – it works as described

Using modern equipment experiment it is easily confirmed, but note …

– Alternating Current (AC) in coil produces sound at twice the frequency
– pulsed Direct Current (DC) produces sound at the pulse frequency

Within 1 year, Bell has advanced his telephone well enough to patent it – Harmonic Telegraph Patent – Feb 14, 1876

By March 10, 1876 Bell has working model using coils wrapped around iron cores that interact with iron diaphragms

The beginnings of the microphone and loudspeaker