All Things Digital

Amateur Radio for the 21st Century

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THE EFFECT OF EDISON "THE WIZARD OF MENLO PARK"— PART 2

Dear Sir:-

Until I received your favor of the 14th instant and a copy of the current issue of Q S T , I was not aware of the fact that the American Radio Relay League issued such a splendid magazine. I have looked over this present number and find it very interesting.

It seems to me that a magazine so ably conducted ought to accomplish much for the advancement of the art in general, and I wish for Q S T a successful future.

It is very kind of you to place your columns open for suggestions which it may be desirable to bring before amateur wireless operators, and some day there may be reason to take advantage of this offer.

Yours very truly,

Thos A Edison

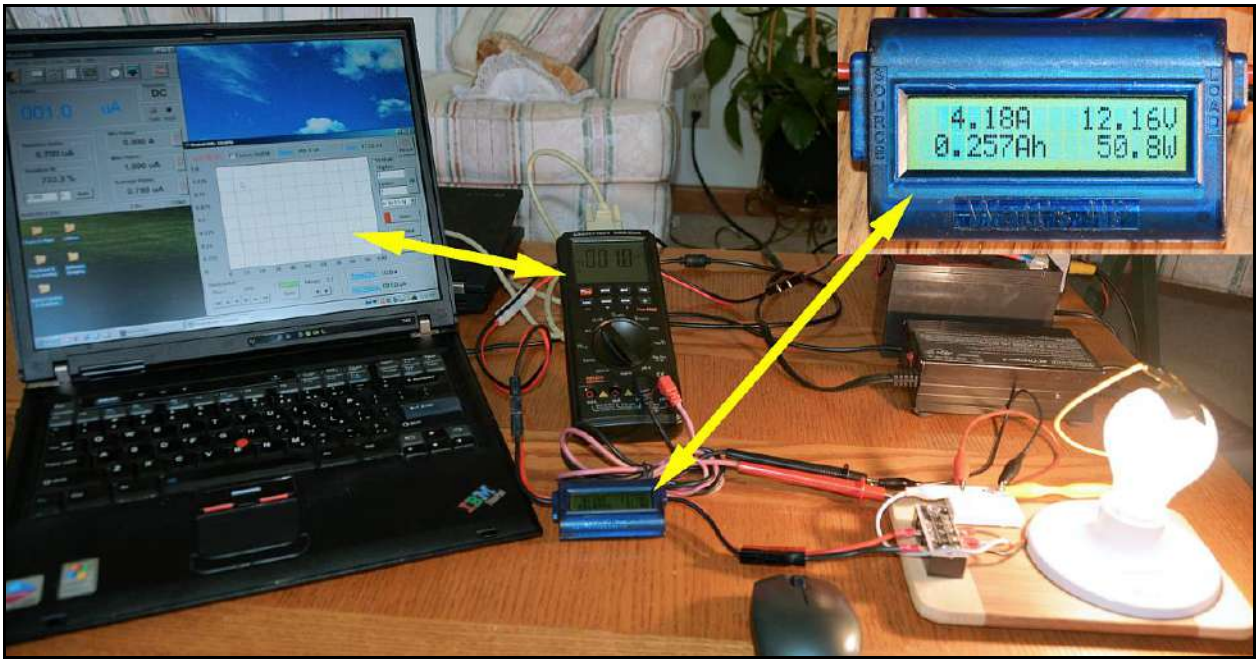
A/2612.

Edison and Early Amateur Radio

Above is a copy of the March 1917 reply letter from Thomas Edison to the young American Radio Relay League (ARRL).

Cofounded in 1914 by Hiram Percy Maxim and Clarence D. Tuska, the ARRL was not only a hobbyist organization—it was a very astute and political one, too. Because World War I had shutdown all non-military radio communications, the ARRL had also written to the U.S. Secretary of the Navy offering the services of its [patriotic] wireless operators, knowing full well that Thomas Edison was the chair of the Navy's new Science and Technology Consulting Board (another "invention" or rather idea of his creation and today's Naval Research Laboratory). Maxim most likely wanted to plant a few favourable "political seeds" of his own because when the War was over, U.S. Amateurs may not be allowed to return to the airwaves. The U.S. Navy had no great love for those blasted "ham-fisted" (19th century pejorative for an incompetent telegrapher), and wanted them gone—forever! In late 1912, after the RMS TITANIC disaster and two boards of inquiry, "hams" were unfairly blamed for the wireless miscommunications and confusion, and the group (world-wide) was "exiled" up to the "useless" shortwave radio bands. So it certainly couldn't hurt to have Edison and also Marconi (who personally apposed the harsh and unwarranted treatment) advocating for you down the road, especially considering their very close relationship. However, even if an offer of a free ARRL membership and/or an invitation to be a contributing columnist was or wasn't politically motivated, it would have put Edison in a conflict of interest. While he had no great love for the admirals involved with his Board (and he told them exactly what he thought of them), he still "played by the rules", and this was why his reply was polite but noncommittal.

On a personal level, Maxim (now middle-aged) had probably wanted to reach out with an olive branch of his own because his late father Sir Hiram Maxim (inventor of the infamous Maxim machine gun) had also invented a version of the incandescent electric lamp (electric light bulb). But because of an inept employee's [supposed] patent filing error, vitriolic court battles ensued with Edison, who won to have his properly filed patent supersede Sir Hiram's. But now, decades later, the elderly Edison likely understood and very much appreciated this truly magnanimous gesture by the son; there is a time when to make war, and a time when to make peace…

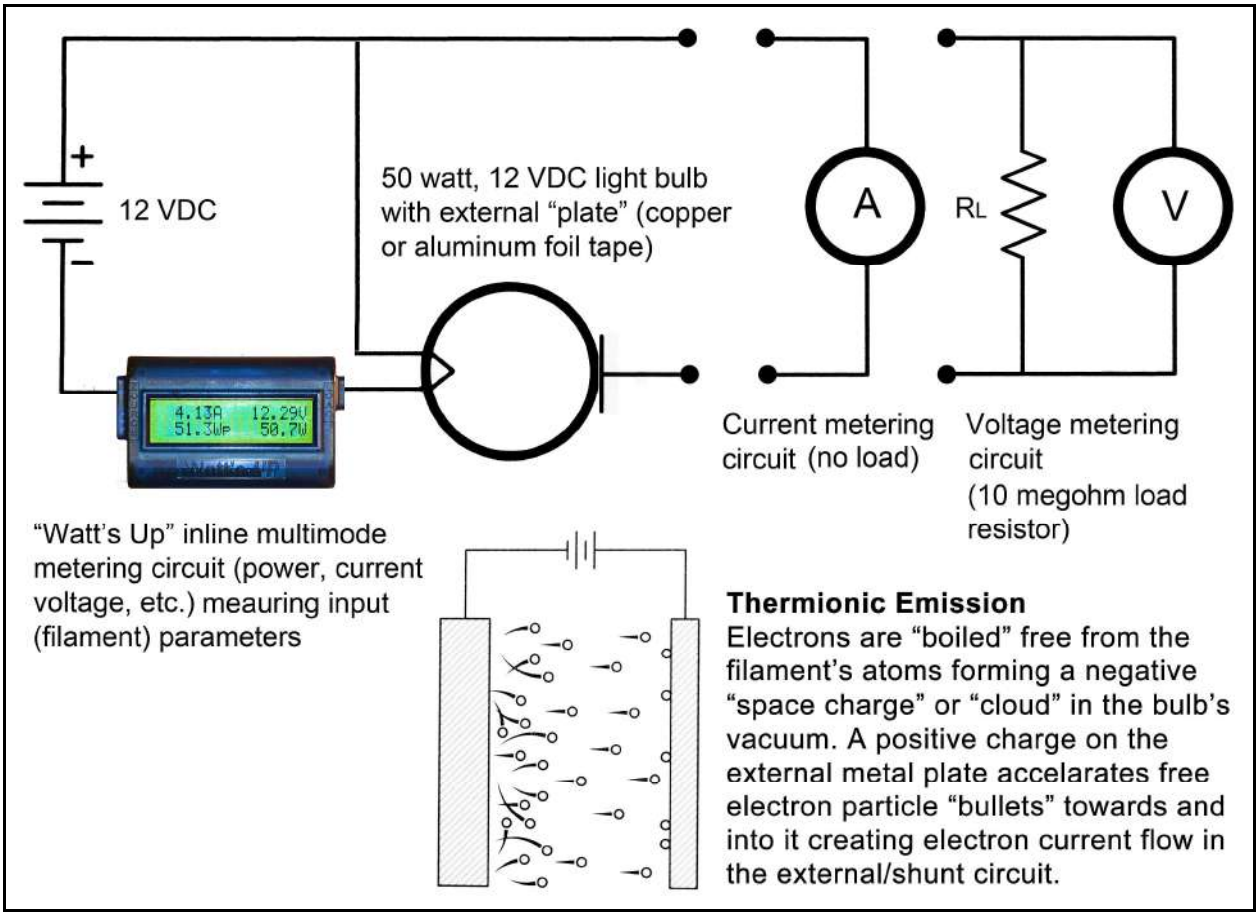


My Edison Effect 21st century experimental living room "laboratory" setup

The Edison Effect Revisited

I was fascinated by Edison's famous discovery of the "Etheric effect" (his term) using high voltage direct current (DC) electric light bulbs (around 110-120 volts). It was actually rediscovered thermionic emission (from heating metals in a forge) except no one realized it at the time because it involved a vacuum and not air. Wanting to replicate his experiment, but lacking such a high DC voltage source, the experiment was scaled down to use a 12 VDC battery and power supply with low voltage incandescent electric light bulbs. My experiment would still reflect Edison's albeit on a smaller scale, albeit with modern atomic foreknowledge. And I could do this because Edison had discovered a current proportionality: "Plate current is directionally proportional to filament current and/or temperature." I.E Doubling filament current doubles plate current; reducing filament temperature 50% reduces plate current 50%. This fact was later used in early 20th century tube detectors as a radio/audio frequency (RF/AF) gain/volume control. However, if the filament current was increased too much, "Poof!" goes the tube up in flames ("tune for smoke" [only]).

Early tubes had “soft” vacuums with some gases and impurities left over inside left in manufacturing process (easier and cheaper to make given their limited market at the time), which also gave them inconsistent electronic performance from one tube to the next. WWI saw the introduction of high-quality, standardized vacuum tube production with pure or “hard” vacuums along with the development of many of today’s electronic circuits. The addition of the control grid between the filament and plate (the “triode”) allowed for safe and very high amplification of RF/AF signals doing away with the need to vary filament current.



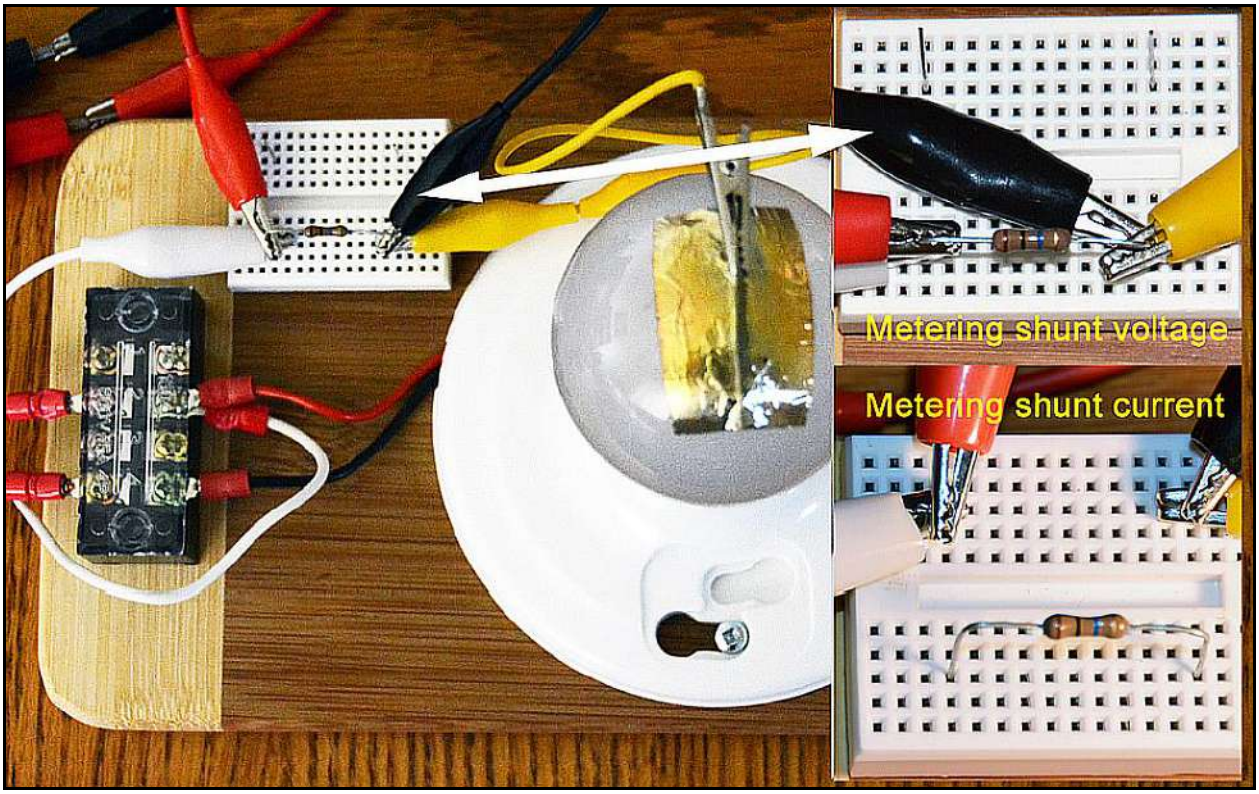
Block diagram of my experimental Edison effect setup

Low voltage light bulbs with aluminum and copper foil external "plates"

The outside shunt circuit plates were made from same sized pieces of copper and aluminum foil tape (see Figure 4) stuck on top of low voltage DC light bulbs. They could easily withstand the high temperature produced on the bulb's surface and still adhere to it; they also made it easy to attach/detach wires using alligator clips. But taking and recording manual readings every minute, for who knows how long, wasn't exactly my idea of summer "fun", but my digital multimeter (DMM) has a serial data [output] port with Windows data logger software to automatically meter (measure), collect, save, and graphically display results in real-time.

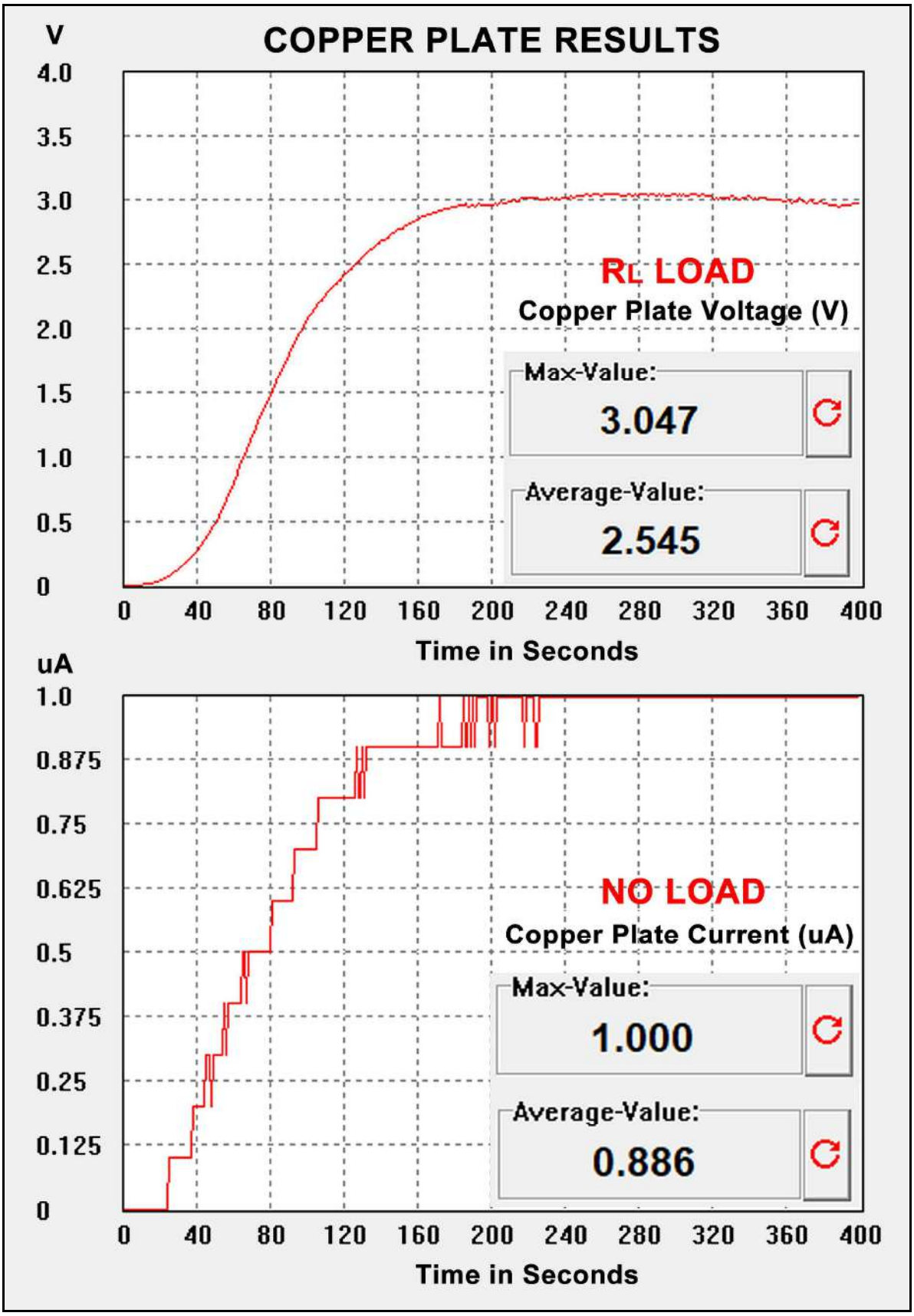
EXPERIMENT ONE (COPPER FOIL PLATE)

The breadboard circuit was designed to make it easier to switch DMM leads and functions between current and voltage measurements (see next page). An adjustable voltage power supply was used to maintain a stable and constant voltage, but it couldn't supply the filament current required so it was paralleled with a 12 VDC battery which could (an old radio operator's trick). The first thing to do was to see if there was any detectable current flowing from the heated filament, across the light bulb's vacuum, into the copper foil plate, and through the shunt circuit.

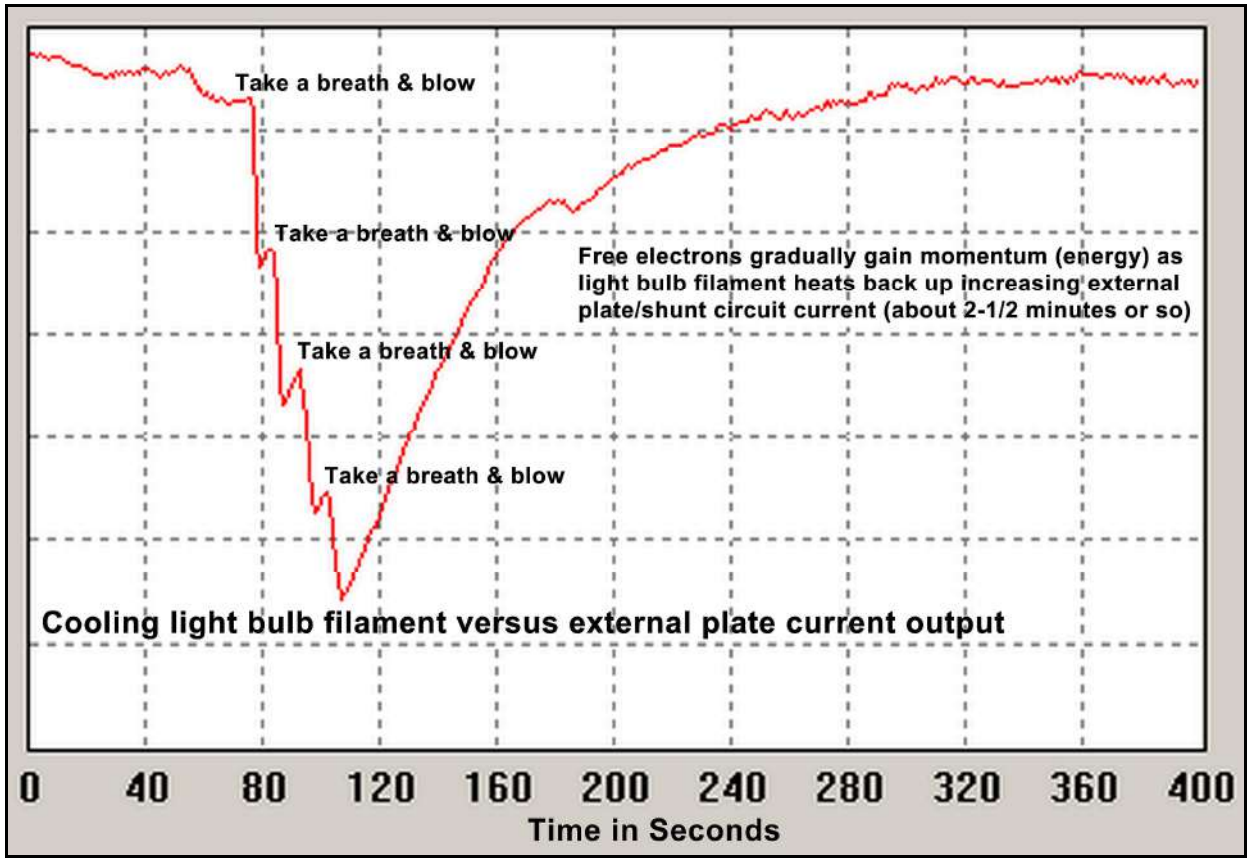


Breadboard circuit showing how shunt voltages and currents are measured

The plate was connected to the positive side of the power supply, and an analog galvanometer (current meter) inserted into the shunt circuit (in keeping with Edison's method) but this was an immediate failure and no current was detected because it wasn't sensitive enough. Switching to a DMM, a miniscule current was measured—success and wow! I can only imagine what Edison was thinking when he did this for the first time. Once the [maximum] value of the [no load] shunt current was known, an appropriate high value load resistor was selected and inserted it into the shunt circuit, and the voltage drop across it measured. It took about 40 seconds before any shunt current was detected and a voltage generated across the load resistor. After that, it gradually climbed, reaching their maximum values and stabilizing after about 240 seconds (see next page).


COPPER PLATE RESULTS
V
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
40
80
120
160
200
240
280
320
360
400
Time in Seconds
RL LOAD
Copper Plate Voltage (V)
Max-Value:
3.047
Average-Value:
2.545
uA
1.0
0.875
0.75
0.625
0.5
0.375
0.25
0.125
0
0
40
80
120
160
200
240
280
320
360
400
Time in Seconds
NO LOAD
Copper Plate Current (uA)
Max-Value:
1.000
Average-Value:
0.886

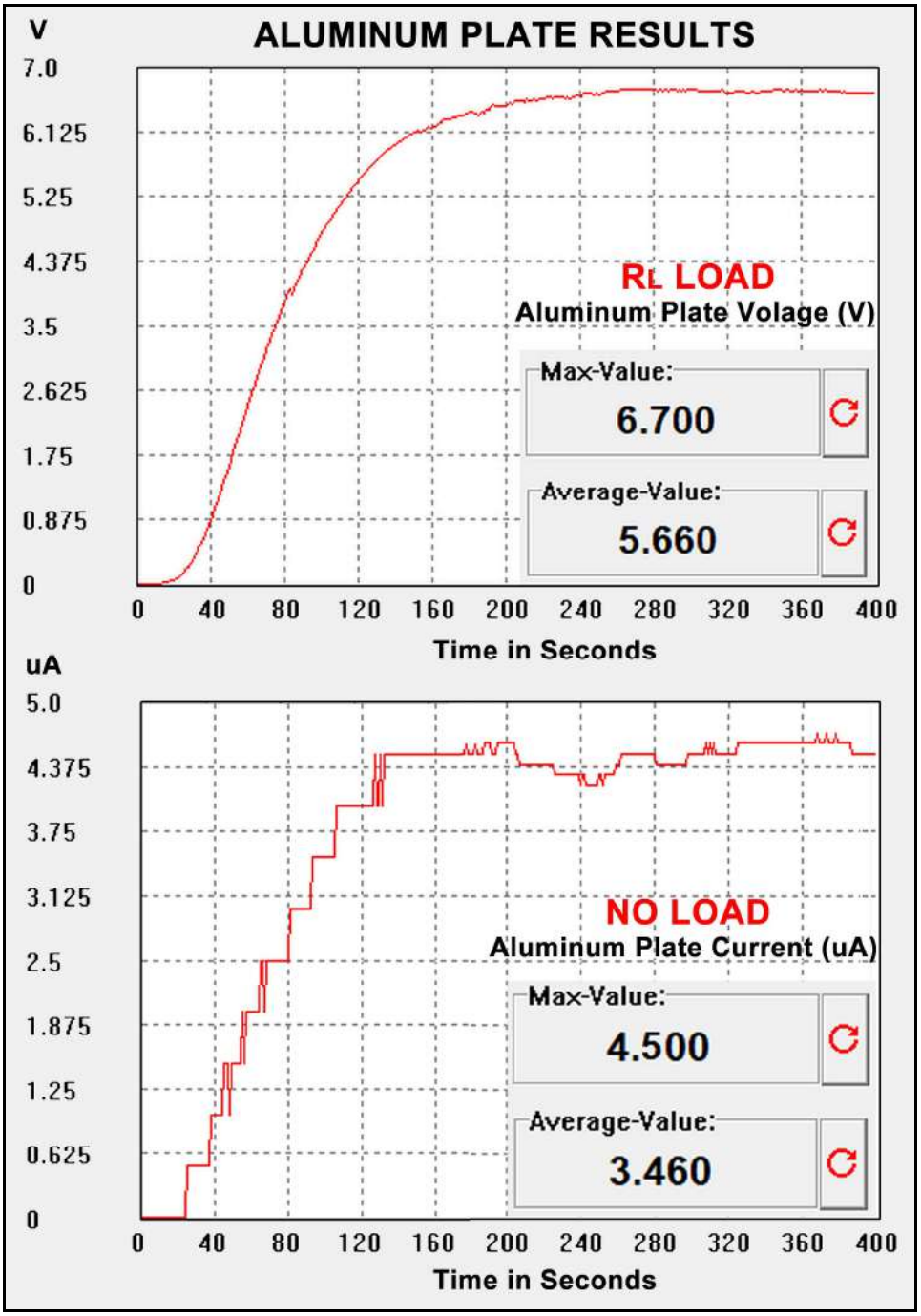
We can use Ohm's Law to calculate the load plate/shunt current (it does the actual work) flowing through the load resistor, which is the load voltage divided by load resistance resulting in 0.3047 microamperes (µA). When the plate was connected to the negative or "ground" side of the power supply, no shunt current was detected and no load voltage was generated.



Now, let's look at the plate current current/temperature proportionality. A high power rheostat wasn't available to control filament current, so how to experimentally show that proportionality exists or doesn't? Well, as Mae West said "Put your lips together and blow…" on the light bulb, that is, which is what I did. This reduced the filament temperature, which in turn reduced the plate current (see above). Okay, I couldn't tell exactly how fast the filament was cooling in relation to how fast the plate current was falling, but we can give Edison the benefit of the doubt and say that it's proportional, but it's definitely linear.

EXPERIMENT TWO (ALUMINUM FOIL PLATE)

Repeating the experiment with an aluminum foil tape plate surprisingly produced a higher no load shunt current and corresponding higher load voltage giving an Ohm's Law calculated plate/shunt circuit load current of 0.67 µA; more than twice that of the copper plate.



Explaining the Results

Why didn't Edison realize that smaller than atoms, negatively charged particles were streaming out from the filament, crossing the bulb's vacuum to the plate, and causing the shunt current he was detecting? Why was he so oblivious to the so obvious? Instead, he thought it was somehow related to the magical properties of the "ether" inside the bulb (hence his name for the effect). Perhaps the light generated inside the bulb crossed the vacuum via the ether when the external plate was positive, and was reflected when the plate was negative? But then he would have had to ask "How can light generate an electric current?"

To answer the question I found an online electronic copy of Dr. Oliver Lodge's (another famous early wireless pioneer) 1889 text book "Modern Views of Electricity" (thank you, Google). In it, you are taught that the atom is the smallest form of matter; a solid, immutable (can't change state or be divided into smaller pieces) electrostatic sphere. Electricity (static, positive, negative, and magnetic) is a form of matter, not a form of energy; it's a Newtonian fluid like water or air, having similar characteristic and behaviour. With such a "modern" view, it's no wonder why none of the greatest minds of science, including Lodge himself, could explain the Edison effect. They all were totally baffled by it. Nikola Tesla speculated that it was some unknown form of matter (a "sub-atom"), which only came into existence within a vacuum, creating a one-way conducting path, but it had nothing to do with electricity itself. The correct answer came in 1897, when physicist J. J. Thomson confirmed the existence and measured the characteristics of an unknown, subatomic, negatively charged particle he called a "corpuscle"—quickly renamed "electron". Electricity, it seems, is energy (electrons) in motion, and a few years later, Einstein explained how light (photons) produces an electric current (photoelectric effect).

My Final

Edison is considered by many to be the "father of electronics", but his genius was so wide and varied that his "effect" is still in many modern industries nearly a century later. He truly was the "Wonderful "Wizard of Oz".—73