

CW for the Radio Amateur

- What is CW?
- History of Morse Code
- Equipment
- Learning CW
- Clubs and Nets

Guglielmo Marconi



- Note: I relied heavily on **The Art and Skill of Radio Telegraphy**, William G. Pierpont, N0HFF <http://n1su.com/contents.htm> in the generation of these materials.

What is CW?

CW (continuous wave) is ham shorthand for radiotelegraphy. It is a wireless version of landline telegraphy and as such, retains some of the old telegraph culture, customs, abbreviations and procedures.

When amateur radio first started, Morse Code was the only way to have two-way communications using an amateur radio. Initially, all Morse Code was sent via spark gap. Within a decade or so, amateur radio moved to continuous wave or CW as only the way to send Morse Code. Eventually spark gap was outlawed (outlawed internationally in 1934) and CW was fully entrenched as the only way to send Morse Code in radiotelegraphy.

I suspect that is when we morphed to calling Morse Code radio telegraphy - CW.

The fundamental problem that led to Morse Code

How can people communicate over distances too far to permit direct verbal communication or where relaying written or verbal messages is too slow or difficult?



Flag Semaphore

From Wikipedia: Flag semaphore (from the Greek σῆμα, sema, meaning sign and φέρω, phero, meaning to bear; altogether the sign-bearer) is the telegraphy system conveying information at a distance by means of visual signals with hand-held flags, rods, disks, paddles, or occasionally bare or gloved hands. Information is encoded by the position of the flags; it is read when the flag is in a fixed position. Semaphores were adopted and widely used (with hand-held flags replacing the mechanical arms of shutter semaphores) in the maritime world in the 19th century. It is still used during underway replenishment at sea and is acceptable for emergency communication in daylight or using lighted wands instead of flags, at night.

Heliography

From Wikipedia: A heliograph (helios (Greek: ἥλιος), meaning "sun", and graphein (γράφειν), meaning "write") is a wireless telegraph that signals by flashes of sunlight (generally using Morse code) reflected by a mirror. The flashes are produced by momentarily pivoting the mirror, or by interrupting the beam with a shutter. The heliograph was a simple but effective instrument for instantaneous optical communication over long distances during the late 19th and early 20th century. Its main uses were military, survey and forest protection work. Heliographs were standard issue in the British and Australian armies until the 1960s and were used by the Pakistani army as late as 1975.

Problems with visual transmissions over distance

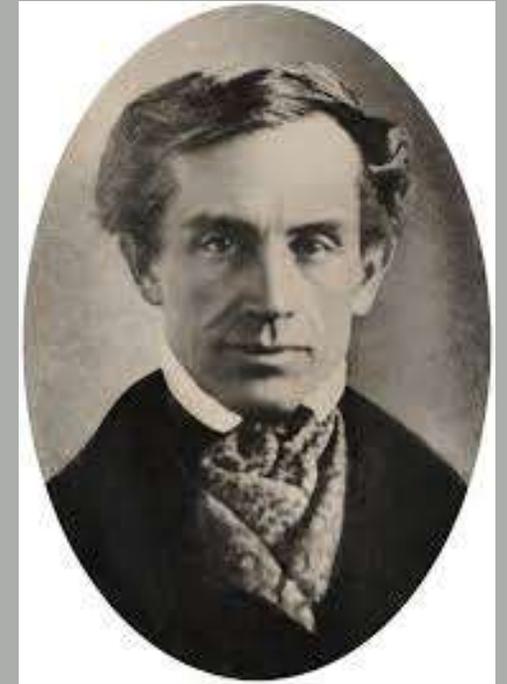
- Interference (weather, topography, darkness, etc.)
- As distance increases, so does difficulty in deciphering (telescopes and binoculars can help with this)
- Absolute limit is line of sight (although relays through others can increase the distance)
- Frequently this type of communication needs more than the sender and the receiver to be effective, i.e., a sender and receiver at each end.

Samuel Morse

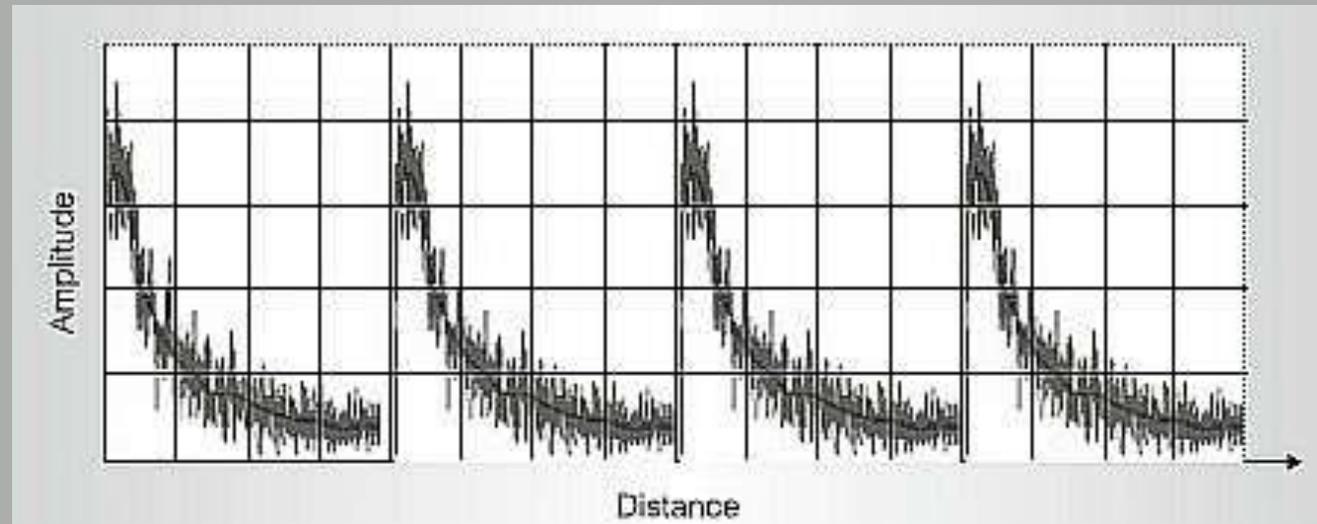
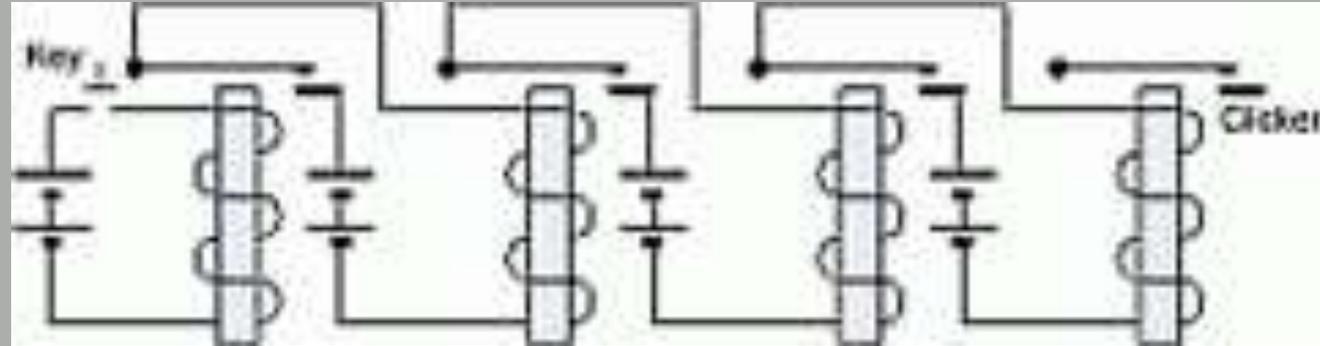
Samuel Morse was an American painter (mostly portraiture). In 1825 Morse was away from home working on a commissioned work (a portrait of Lafayette). He received a letter that said his wife was ill. The next day he got another letter explaining his wife had died. He headed for home and by the time he got there she had already been buried. Reportedly this caused him to explore means of faster ways to communicate over distances.

In 1832, he learned about electromagnetism. **Morse's insight:** Use of electromagnetism with linear coding could permit long distance transmission of information over a single wire.

Morse and Leonard Gale developed a form of repeater using electromagnetic relays (i.e., a non-linear amplifier) to permit signals to be sent over longer distances than the few hundred-yard range which served to limit the use of wired telegraphy. The big test was two miles and it proved the concept. Then Congress appropriated funds for a 38-mile demonstration.



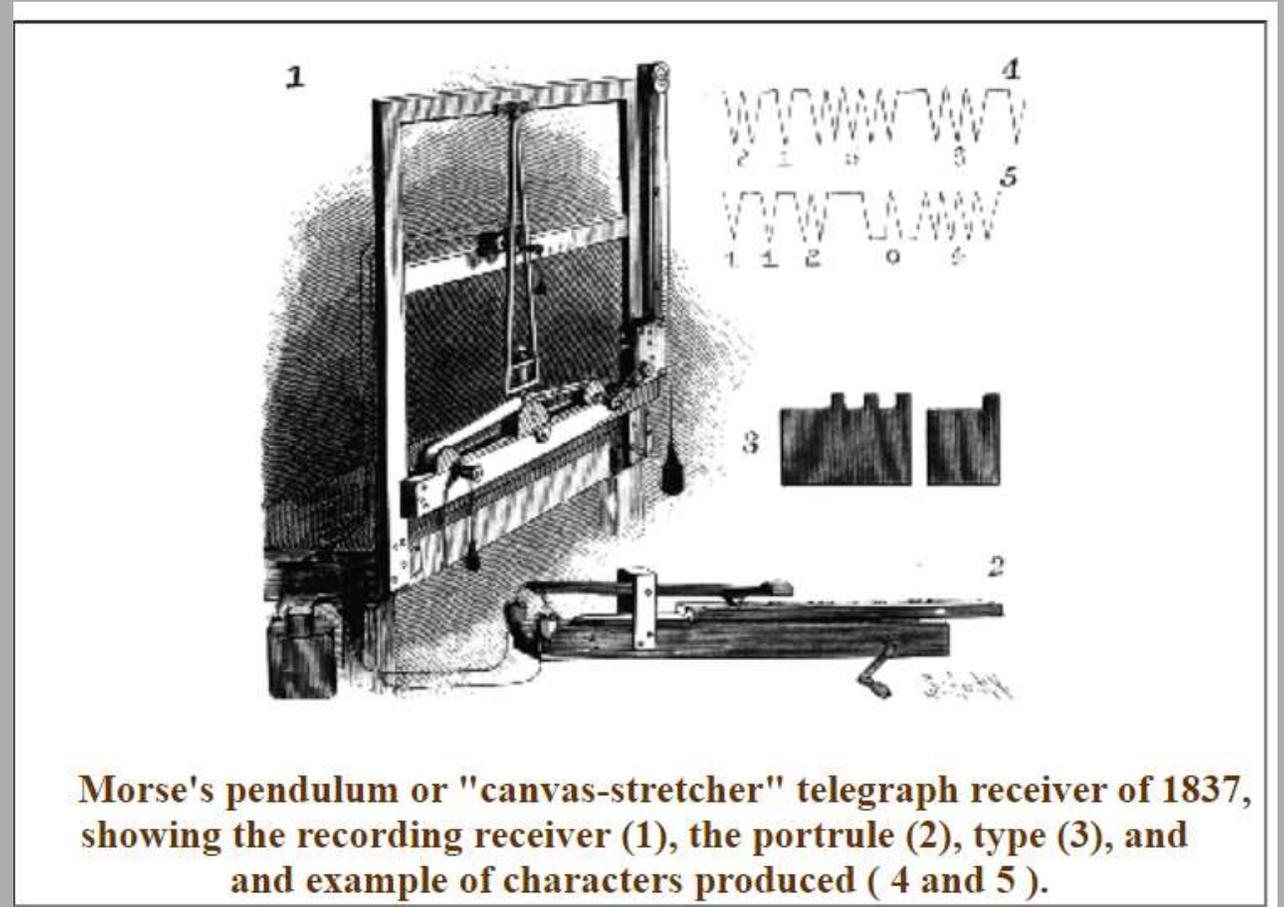
Morse's Repeater Circuit resulted in a patent



Wire stretched from the key position to the point that the signal faded at which point a relay operated to control higher voltage to retransmit the signal – essentially operating as a repeater.

Issues that Morse needed to solve

- Equipment
 - Morse spent his energy on a self-recording system that marked on a strip of paper and which could be read by the operator visually
- A usable code
 - Morse was attempting to create a code book that would allow a number to be used to represent each word



Morse's pendulum or "canvas-stretcher" telegraph receiver of 1837, showing the recording receiver (1), the portrule (2), type (3), and example of characters produced (4 and 5).

Alfred Vail is thought to be the true inventor of what is known as Morse Code

- Vail is believed to have created what is now known as Morse Code
- Vail created a telegraph key and sounder
- Vail's code became known as Morse Code and ultimately Morse who had taken all the credit for developing Morse Code, apparently tried to set the record straight and tell the world that Alfred Vail had invented the code.



American Morse Code

- American Morse Code had these elements:
 - Dot
 - Dash
 - Longer Dash
 - Space
 - Longer internal spaces
- American Morse Code was used in the USA until after the early 20th Century, about 1927. One perceived advantage was that it could be sent faster than International Morse Code.

Development of International Morse Code

- In 1852, the Germans and Austrians agreed to unify Morse Code under the following principles (which still apply):
 - Uniform dot and dash element lengths
 - Letters were no longer than four elements long
 - Numbers were to be 5 elements long
 - Punctuation was to be 6 elements long
- In about 1865 at a telegraph convention in Paris, some of the letters were modified and was called the “Continental” code until wireless was invented and thereafter it was known as “International”
- Some punctuation revisions were made in the 1930s

Comparison of American Morse and ITU Morse

	American (Morse)	Continental (Gerke)	International (ITU)
A	••	••••	••
À	••••	••••••	••••
B	•••••	••••••	•••••
C	••••	••••••	•••••
CH	••••	••••••	•••••
D	••••	••••••	•••••
E	••	••	••
F	•••••	••••••	•••••
G	•••••	••••••	•••••
H	•••••	••••••	•••••
I	••	••	••
J	•••••	••••••	•••••
K	•••••	••••••	•••••
L	•••••	••••••	•••••
M	•••••	••••••	•••••
N	•••••	••••••	•••••
O	•••••	••••••	•••••
P	•••••	••••••	•••••
Q	•••••	••••••	•••••
R	•••••	••••••	•••••
S	•••••	••••••	•••••
T	••	••	••
U	•••••	••••••	•••••
Û	•••••	••••••	•••••
V	•••••	••••••	•••••
W	•••••	••••••	•••••
X	•••••	••••••	•••••
Y	•••••	••••••	•••••
Z	•••••	••••••	•••••
1	•••••	••••••	•••••
2	•••••	••••••	•••••
3	•••••	••••••	•••••
4	•••••	••••••	•••••
5	•••••	••••••	•••••
6	•••••	••••••	•••••
7	•••••	••••••	•••••
8	•••••	••••••	•••••
9	•••••	••••••	•••••
0	•••••	••••••	•••••
0 (nl)	••	••	••

Problems with American Morse Code

- The additional elements made it more difficult to send and to copy
- The additional elements increased the possibility of confusion or mistakes

Copying the code by sound rather than looking at the recorder

- The original Morse system used a “recorder” so that the messages could be “read” visually
- Operators noticed that they could understand the code by hearing it as it marked the messages for visual reading
- Using hearing to understand messages was fought until someone proved it could be done accurately, from there on, copying by hearing the transmission took over

Spread of Morse Code Telegraphy

- According to Marshal Emm, N1FN (he's the owner of Morse Express in Aurora):
 - in 1844, when Morse's initial demonstration was made, there were 38 miles of lines (Baltimore to Washington).
 - By 1850 there were already 12,000 miles of telegraph lines in use
 - By 1900, there were hundreds of thousands of miles of telegraph lines all over the world.

Tickers

- Printing telegraphs were informally known as “tickers” and until relatively recently were used to distribute news and information directly to customers
- These became widely used for the distribution of stock and bond prices
- One could go to the stock brokerage house and sit in a room where there were ladies who took the paper “ticker tape” and copied the results onto a chalk board showing the most recent stock and commodity trades



Watching the ticker tape, 1918



Land telegraphy evolved into wireless telegraphy

- Marconi worked on wireless telegraphy beginning in the early 1890's. At that time, many others had also been working on sending telegraphy wirelessly.
- In 1895, Marconi devised a system with an oscillator, an aerial, a coherer receiver (a tube with two electrodes close together with loose metal filings, when RF is applied, the filings cling together and reduce the resistance allowing current to pass more easily, after each signal, it had to be "de-cohered" by tapping to break apart the filings), a telegraph key and a telegraph register activated by the coherer
- Using this system, he believed that antenna height was key, but he later discovered that grounding the system permitted him to transmit over two miles.
- On December 17, 1902 Marconi transmitted from Glace Bay Nova Scotia, Canada to Ireland and the era of radio telegraphy was well under way

Spark gap transmitters:

- Originally, Morse Code was sent wirelessly (as contrasted with being sent over a telegraph wire) by a spark gap transmitter originally developed by Heinrich Hertz.
- Radio waves can be generated by time-varying electric currents flowing through a conductor that suddenly change velocity.
- A spark gap transmitter used a capacitance discharge through an electric spark across a spark gap. The spark doesn't produce the radio waves, it excites the resonant radio frequency oscillating electric currents in the remainder of the circuit. Given the inherent inductance of the circuit, the discharge of a capacitor through a low enough resistance, such as through a spark, is oscillatory – the charge flows rapidly back and forth through the spark gap for a brief period until they die down – like ringing a bell.

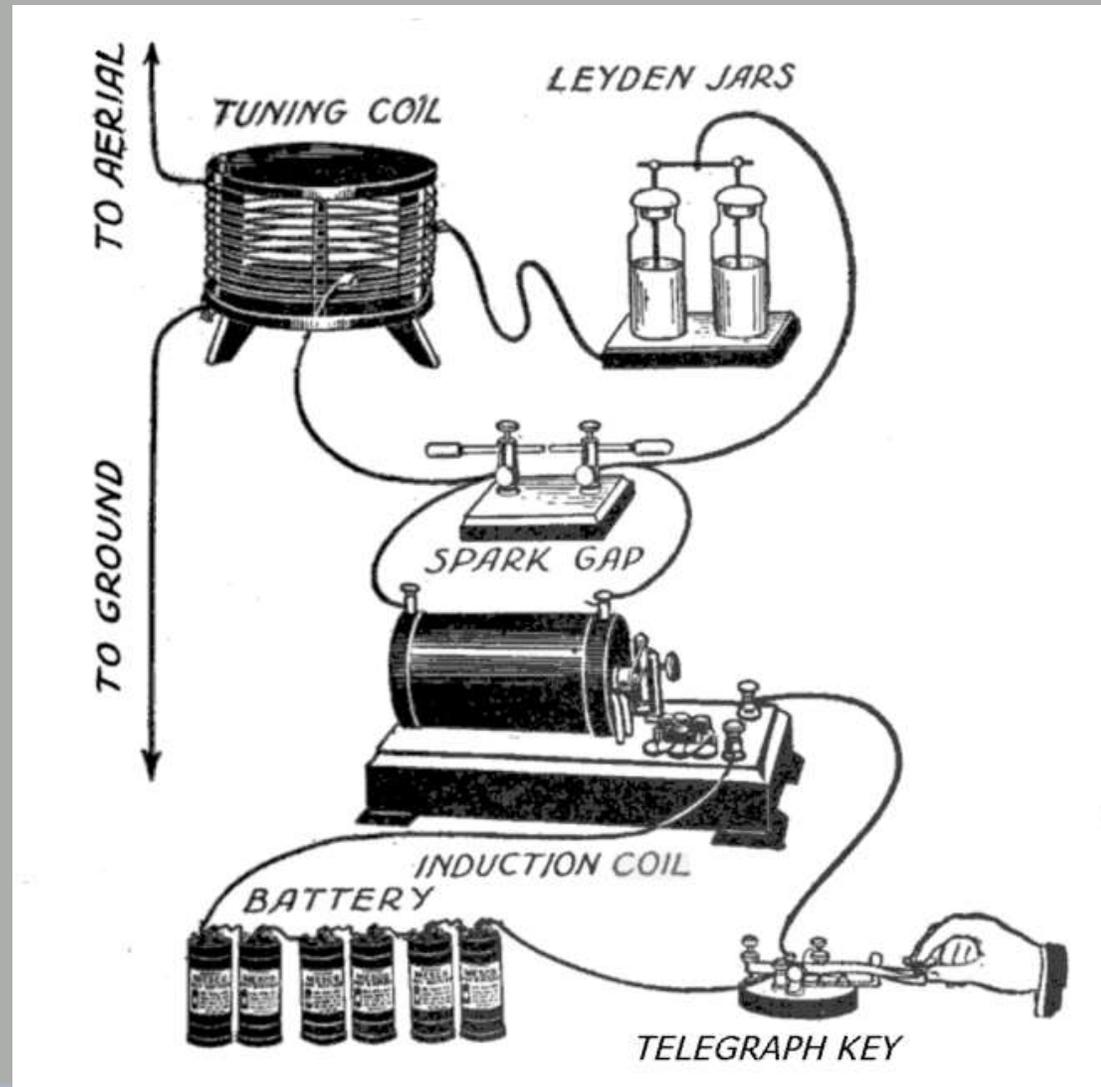
How a spark gap transmitter was constructed:

- To create a spark gap transmitter:
 - High voltage transformer to increase the power source up to a few kilovolts (75 – 100 kV) sufficient to permit the charge jump across the spark gap which has a very low resistance – less than an ohm.
 - One or more resonant circuits (tuned or tank circuits) to create the needed RF oscillations which start with a high amplitude and decrease exponentially to zero, called a dampened wave.
 - In the earlier versions, the antenna acted as a resonator, completing the resonant circuit. The frequency is determined by the resonant frequency of the circuit, which when constructed as a tank circuit, is determined by the capacitance and inductance of the components.
 - Most had an air core transformer known as a resonant transformer or oscillation transformer (i.e., an inductively coupled transformer) converted the oscillating current from the spark gap circuit into an oscillating magnetic field that induced current in the secondary coil

How a spark gap transmitter operated:

- The capacitor was charged to a high voltage and discharged through the coil by a spark across the gap. This causes it to “ring” like a bell, producing a brief oscillating current which is radiated as electromagnetic waves by the antenna
- The transmitter repeats at a rapid rate (each cycle taking less than a millisecond) so that the spark appears to be continuous and the radio signal sounded like a whine or buzz in the receiver.
- Each spark created a sinusoidal wave that increases rapidly to a high amplitude and decreases exponentially to zero, this is called a dampened wave.
- The frequency is determined by the resonant frequency of the resonant circuit
- The operator’s key was used to turn the transmitter on and off

Simple spark gap transmitter



Spark gap's disadvantages:

- Large bandwidths which interfered with adjacent signals.
- Generated loud noise when in use
- Produced corrosive gas when used which eroded the electrodes and created fire hazards

Continuous waves

- Spark gap transmissions were dampened waves which spread energy over a wide band of frequencies. The slower the decay of the dampened wave, the narrower the bandwidth. The government encouraged limitations on the rate of dampening to limit crowding of the radio spectrum.
- This led to the realization that the ideal wave would be a sine wave with zero dampening – all of the energy would be focused at a single frequency (plus a little for the skirts related to key down and key up transitions).
- Continuous waves are produced by an oscillator circuit

Advantages of using continuous waves:

- Continuous waves have an advantage over dampened waves because energy is focused at a single frequency, thereby limiting interference with adjacent signals
- Could be used to transmit over longer distances with the same output power
- Early versions did not permit “break-in operation” because the carrier wave was not turned off between elements or characters (as it was with spark gap transmitters)

Why use continuous wave (CW) rather than AM or SSB?

- It can be used with simpler equipment (no need for voice related circuitry or handling computations)
- It's a more efficient use of spectrum than SSB (bandwidth can be as low as 50 Hz vs 2.4 kHz)
- CW has a power on transmission advantage over SSB
- The audio for CW is essentially on or off (very close to a square wave – the skirts are sloped, however) whereas SSB relies on modulation across the sent signal width – so CW is easier to copy than SSB as you get closer to the noise floor. Some data modes are more efficient than CW when you get down to the noise floor.
- Smaller band width = Lower noise therefore lower signal to noise ratio (several data modes beat even CW with respect to narrow band width).

Simplified equipment for CW

Simplified CW Block Diagram:

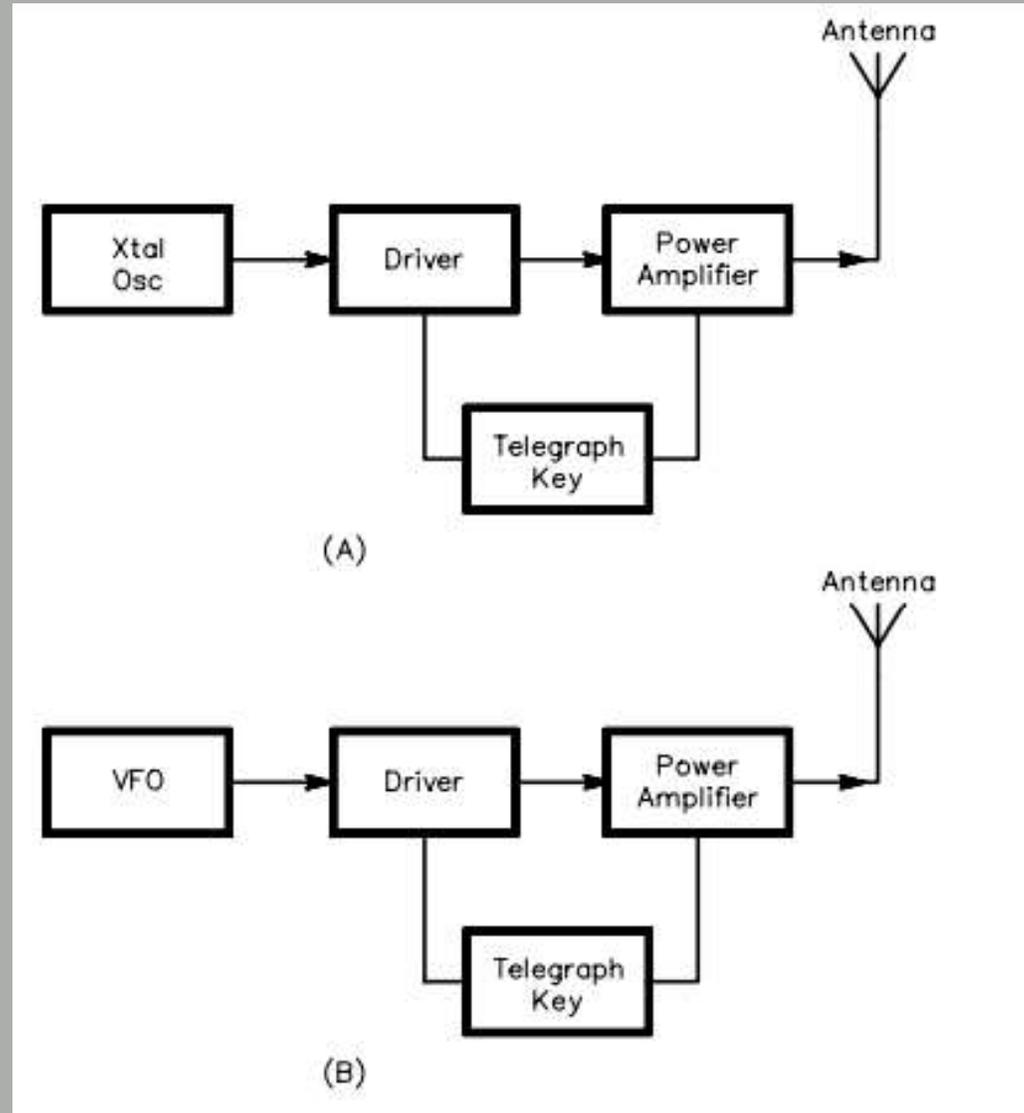


Diagram from ARRL

Power output is more concentrated

- Since the CW signal bandwidth is a fraction of the bandwidth for SSB, the same power from the transceiver generates a several dB advantage for CW:
 - Bandwidth of CW is dependent on speed of sending and on the shape of the waveform. Assuming 25 wpm sending speed, the following is a close approximation:
 - SSB signal takes 2000 Hz therefore average power density at 100W is .05 W/Hz (i.e., 100 W / 2000 Hz)
 - CW signal at 25 wpm with 100 Hz bandwidth has a power density of 1 W/Hz (i.e., 100 W / 100 Hz).
 - Gain of CW over SSB = $10 \log(1/.05) = 13 \text{ dB}$ (approx.).

Concentrating on HF amateur communications a DXer is focused on long distance, usually weak, signals. Different modulation modes inherently have different performance on weak signals. Let's look at some common modes used for DXing. It is common in the amateur radio literature to express SNR performance, ie the ability to hear and decode weak signals, in dB relative to noise in a 2500 Hz bandwidth. This is what we show in Figure 2.

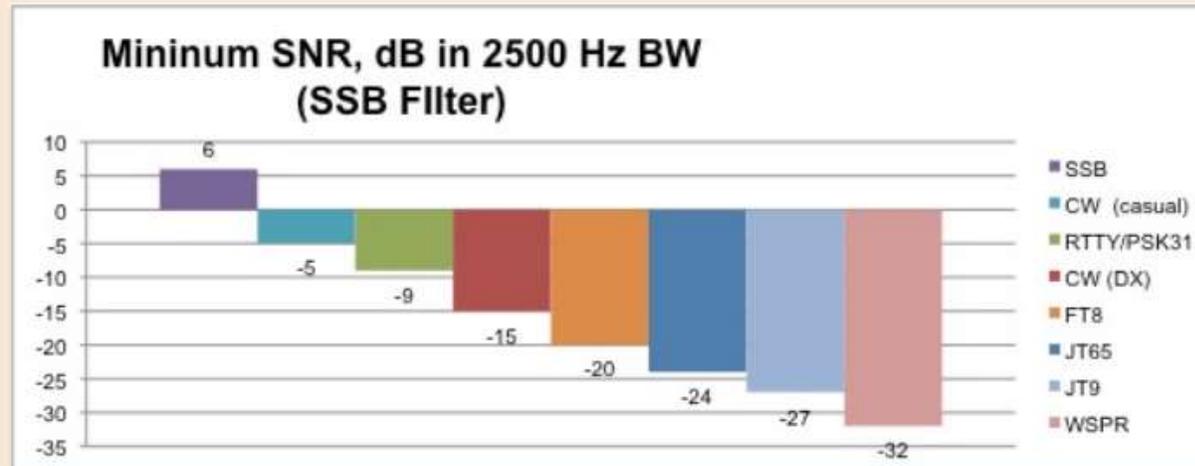


Figure 2: SNR performance referenced to casual copy SSB signal in 2500 Hz

As shown in Figure 2 a 6dB SNR is required for casual SSB communications. A just barely understandable SSB signal (recognize your call and pull in a signal report) would be 0 db SNR. Note that when we do these SNR comparisons it is on a clear channel. No QRM, no static crashes, no fading. To compensate for these channel characteristics we would need a higher SNR.

Looking at Figure 2 we see for casual CW operation the signal can be 11 dB lower or -5 dB SNR for the same intelligibility as casual SSB. But what does -5 db mean? Doesn't that mean the signal is below the noise? How can you hear that! Remember this is relative to a 2500 Hz bandwidth. You would normally click in a 500 Hz filter and now the -5dB becomes 1.8dB. That's good enough to copy CW. Still too noisy for you? click in the 250 Hz filter and now you have SNR=4.8dB.

Is CW USB or LSB?

- Since CW is a single frequency, it isn't USB or LSB
- Modern rigs receive CW signals just like they receive SSB or AM signals. One sets the "pitch" as an offset from the frequency shown on your rig and by having the CW tone at that higher frequency it is at an audible frequency and that is what is heard. Your rig shows the correct frequency of the signal but tunes so that the signal is audible at the frequency offset you select.
- I have mine set at 600 Hz – since I have a Yaesu rig, that offset is referred to as USB even though that designation is really not accurate. So I hear the tone at +600 Hz, but the VFO displays the carrier frequency that is 600 Hz lower (0 Hz offset). As I understand it, the practice for ICOM is the reverse (i.e., LSB). The primary difference is turning the VFO clockwise will cause the tone to rise on one rig and to fall on the other type of rig.
- If there is interference at +600 Hz, I can switch to CW-R so that the offset is -600 Hz (i.e., a 1,200 Hz shift from +600 Hz) and still hear the signal

Suggested Resources – CW for amateur radio

- **The Art and Skill of Radio Telegraphy**, William G. Pierpont, N0HFF
<http://n1su.com/contents.htm>
- **Zen and the Art of Radiotelegraphy**, Carlo Consoli, IK0YGI
https://www.qsl.net/ik0ygi/enu/ZART_r20101008m.pdf
- **Improving Morse Code Proficiency Tricks of the Trade Overcoming common Problems**, J. A. (Jack) Ritter WØUCE
<https://static1.squarespace.com/static/58f4e114be6594c2f9bcc9f6/t/594815ccb8a79b8f7c706eb1/1497896396974/Overcoming+Problems.pdf>
- **The Road to CW**, Christian Bravo, W4ALF
http://www.k4co.org/MiscDocuments/Road_to_CW_de_W4ALF.pdf
- **Learning Morse Code as a Language**, J. A. (Jack) Ritter WØUCE
<https://www.kb6nu.com/wp-content/uploads/2017/11/LearningMorseCodeasaLanguageVersion2.6June2015.pdf> – Note: this seems a bit involved for me.

More CW Resources:

- **DitDit.fm**, The Podcast for Morse Code and CW Operators
<https://www.ditdit.fm/>
- **AD0WE** QRZ page of Kurt Zoglemann - look him up on QRZ, his callsign is AD0WE

Morse Code and amateur radio licensing

- According to Pierpont:
 - From 1913 to 1933, an Amateur First Grad needed to pass 5 wpm (in August 1919, this was increased to 10 wpm).
 - In 1923, a new Extra First Grade license was created, including code speed test at 20 wpm (note: this is the same speed as a Commercial First-Class Operator was required to pass)
 - The Radio Act of 1927 replaced the Radio Act of 1912 there were multiple classes of licenses introduced and each of them required 10 wpm code proficiency
 - Commencing in 1936 code speed for all classes was increased from 10 wpm to 13 wpm
 - In 1951, Extra Class was 20 wpm, General and Technician required 13 wpm, the new Novice class was 5 wpm.
- Effective February 23, 2007, Morse Code was no longer required for any class of amateur radio license in the USA

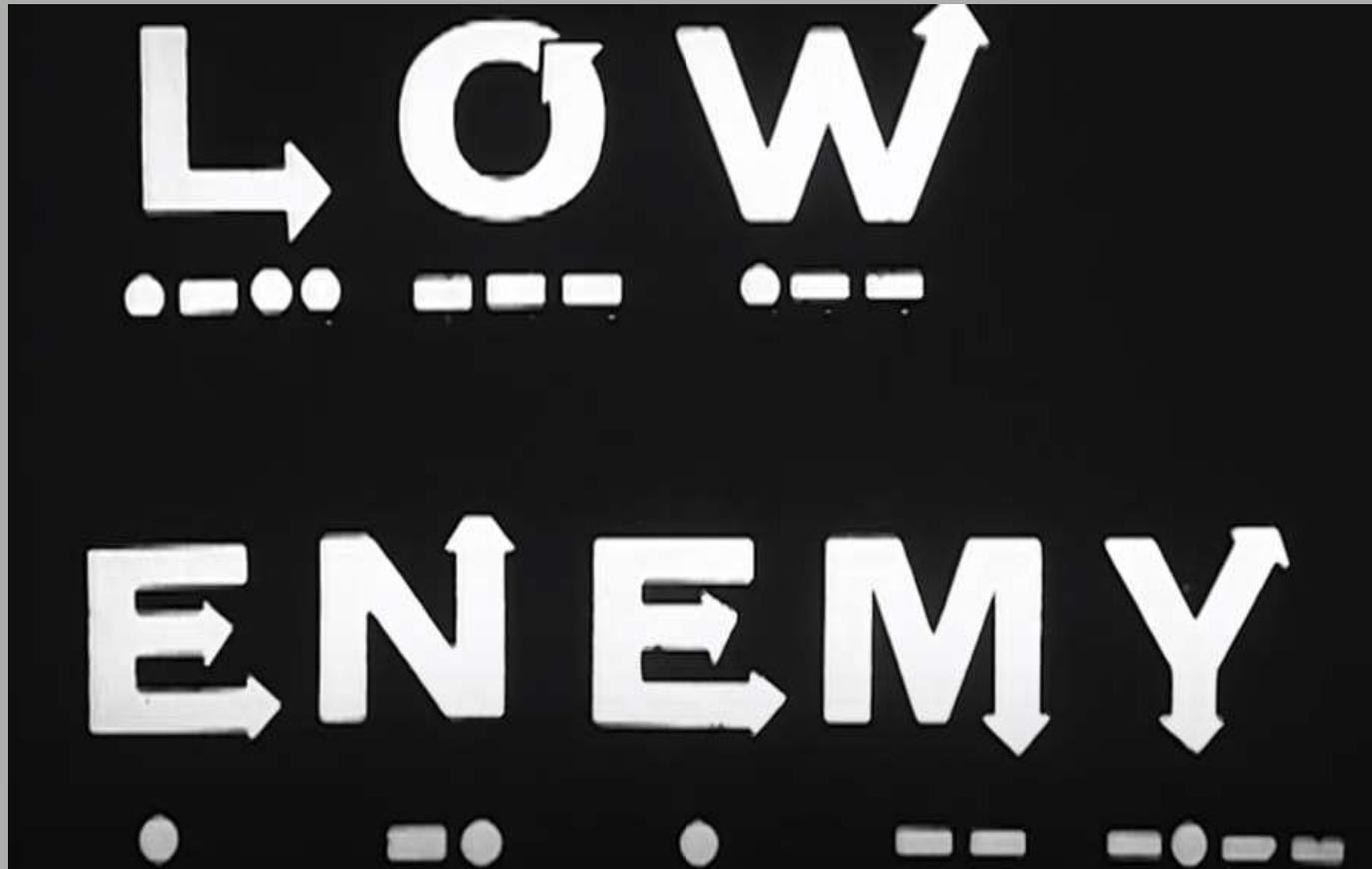
Timing and spacing

- Definitions:
 - Elements – the dits and dahs that make up a character
 - Character – a letter, numeral, punctuation mark, or Prosign
 - Prosigns (short for procedural signs) – symbols formed by running two characters together without intercharacter spacing(e. g. , AR = end of message, AS = Standby, BK = invite receiving station to transmit, SK = end of contact/work, KN = go only, invites specific station to transmit)
- Timing – this is the gap between the elements of a character
- Spacing – this is the gap between letters and words
- Proper timing and spacing:
 - A dit length is one
 - A dah length is three
 - The time between elements of a character is equal to one
 - The spacing between characters is equal to three
 - The spacing between words is equal to seven
- Precision Fist Checking <https://www.qsl.net/dj7hs/download.htm>
- CWGet <https://www.dxsoft.com/en/products/cwget/>

How timing and spacing matter

- The word “an” is sent didah dahdit. 
- If the timing between the characters is wrong, If the timing and/or spacing is wrong,
 - it can come out as separate letters
“a” and “n” didah dahdit 
 - it can come out as “P” didahdahdit 
 - It can come out as “we” didahdah dit 
 - Compare “an,” “a” “n,” “p” and “we” 
- Timing and spacing really matter as shown by the following examples from the US Army Signal Corps

Timing issues (same elements, different timing):

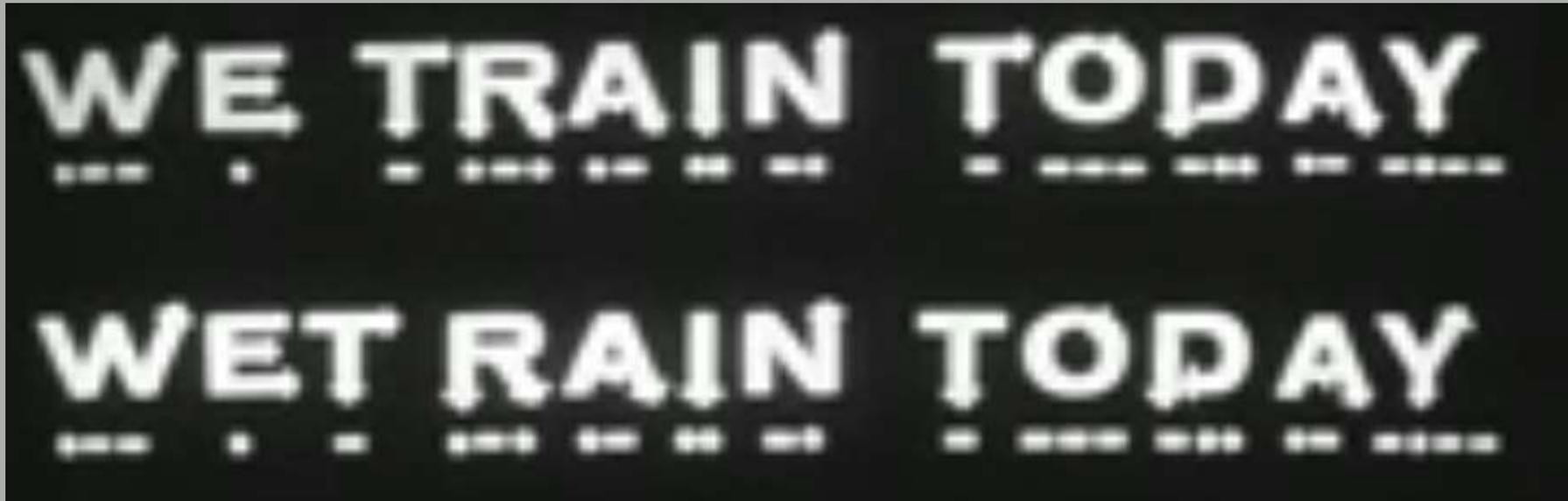


Spacing issues (same characters, different spacing):



Army Morse Code pt. 01

More spacing issues (same characters, different spacing):



Morse Code Part Two - Principles and Basic Techniques (US Army Signal)

Calculating speed

The word PARIS is the standard for determining Morse Code Speed:

- A dit is one element
- a dah is 3 elements
- Intra-character spacing is 1 element
- Inter-character spacing is 3 element
- Inter-word spacing is 7 elements

P – di da da dit
1 1 3 1 3 1 1 (3) = 14 elements

A – di da
1 1 3 (3) = 8 elements

R – di da dit
1 1 3 1 1 (3) = 10 elements

I – di dit
1 1 1 (3) = 6 elements

S – di di dit
1 1 1 1 1 (7) = 12 elements

14 + 8 + 10 + 6 + 12 = 50 elements

Code Proficiency Certificates are available through a program sponsored in part by Vibroplex. All that you need to do is to have one minute of solid copy of a W1AW Qualifying Run and submit it to the ARRL with \$10.00 (\$7.00 for increased speed indorsements) and you will get a certificate. Qualifying Runs are broadcast twice per month on several bands at speeds from 10 wpm to 35 wpm.

Call sign weights

- WOGAS = 62
- WORLY = 72
- KONR = 52
- WGOAT = 60

FISTS has a call weight calculator that shows the time it takes to send a call sign – the lower the number, the faster to send

<https://fistsna.org/callweight.php>

Types of Keys

- **Straight keys** – simple down motion completes the circuit where the time the contacts are together determines whether a dit or a dah is keyed.
- **Double Speed Key, Sideswiper, or Cootie Key** – a more complicated key that completes the circuit with motion to the left or right, but purely mechanical, no keyer. The operator can send dits or dahs by pressing to either side and each element of a character is created by pressing to the opposite side, i.e., alternating sides regardless of what the element being sent is.
- **Bug** – sometimes called a Vibroplex Key. A side to side key. When pressed to the left, dahs are created. When pressed to the right, a horizontal pendulum is set in motion which rocks against the contact points creating a series of dits. The speed is controlled by the positioning of a pendulum weight.
- **Paddle or paddles**
 - Keyer controlled by single paddle
 - Keyer controlled by dual paddles, which can be iambic or not
 - Paddle types:
 - Mechanical with springs to reopen the contacts
 - Mechanical with magnets to reopen the contacts
 - Capacitive – added capacitance from touching the contacts triggers the element being sent (remember those time constants)
 - So-called resistive key where touching the contacts completes a circuit and triggers the element being sent
 - Solid state CW Paddle (keying occurs by pressure [10 gr. to 50 gr.], the paddle does not move)
- **Keyboard**

Iambic Keying:

As described by Marshal Emm, N1FN (owner of Morse Express):

An iambic keyer is simply an electronic keyer that can be operated with a dual paddle (see below), and responds to a closure of both levers at the same time by sending a series of alternating dots and dashes. The term "iambic" describes the rhythm of the alternating dots and dashes. It comes from poetry, where an "iambic meter" is a rhythmical pattern of alternating stressed and unstressed syllables. For example, "twas BRILLig AND the SLITHey TOVES did GYRE and GIMbal IN the WABE." That line from Lewis Carroll's Jabberwocky is actually "iambic heptameter" if anyone is counting. Poetry teachers used to vocalize this iambic meter or rhythm as "deDum deDUM deDUM" which sounds a lot like "di-dah di-dah di-dah." An iambic keyer will send "di-dah di-dah di-dah." as long as both paddles are held closed (or "squeezed," – if the dot lever is pressed a little bit before the dash lever. If the dash lever is pressed first, the keyer will send "dah-di dah-di dah-dit.", or DUMde instead of deDUM. Those of you who didn't sleep through English 101 will remember that the latter rhythm is called trochaic, so the "iambic keyer" could just as well be called the "trochaic keyer," or the "iambic/trochaic keyer."

Keystroke comparisons:

Number of keystrokes needed to send the alphabet plus the numbers 0 - 9:

Type of Key	Number of movements
Straight Key	132
Semi-Automatic Bug	87
Non-iambic Electronic Keyer	73
Iambic Electronic Keyer	65

From K4FN attributed to K7QO

Is Iambic Keying a Huge Advantage?

- According to N4FN, iambic keying is not really a huge advantage over non-iambic keying – the reason is that iambic keying only is used on some letters and they are used infrequently in radiotelegraphy. Further, keep in mind that Morse Code is already optimized based on usage frequency of the letters.
- N4FN estimates the benefit is on the order of 4% to 6% and he argues that using iambic keying isn't worth the effort and further asserts that at higher speeds, senders move away from iambic keying

J-38 Key



HM-HK707



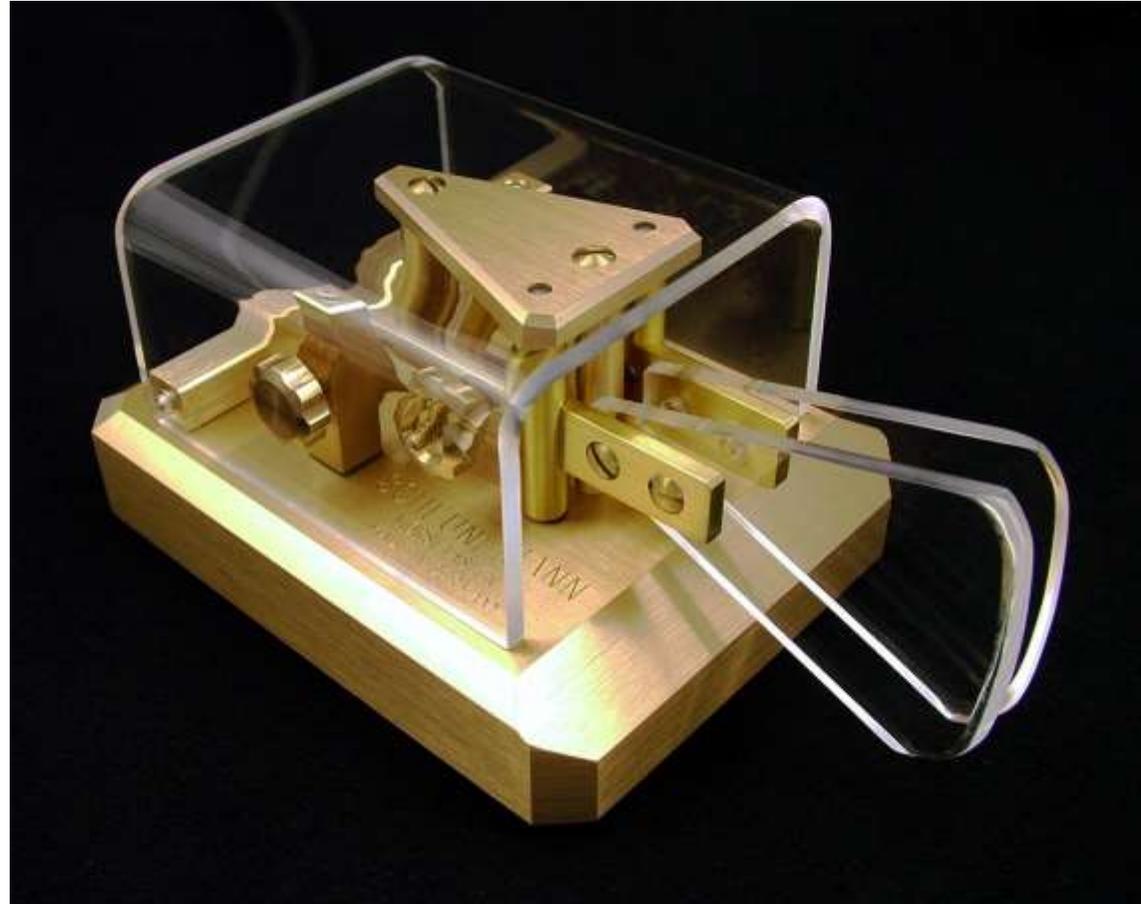
Cootie key



Bug – Vibroplex Blue Racer



Scheunemann paddle:



Begali paddle:



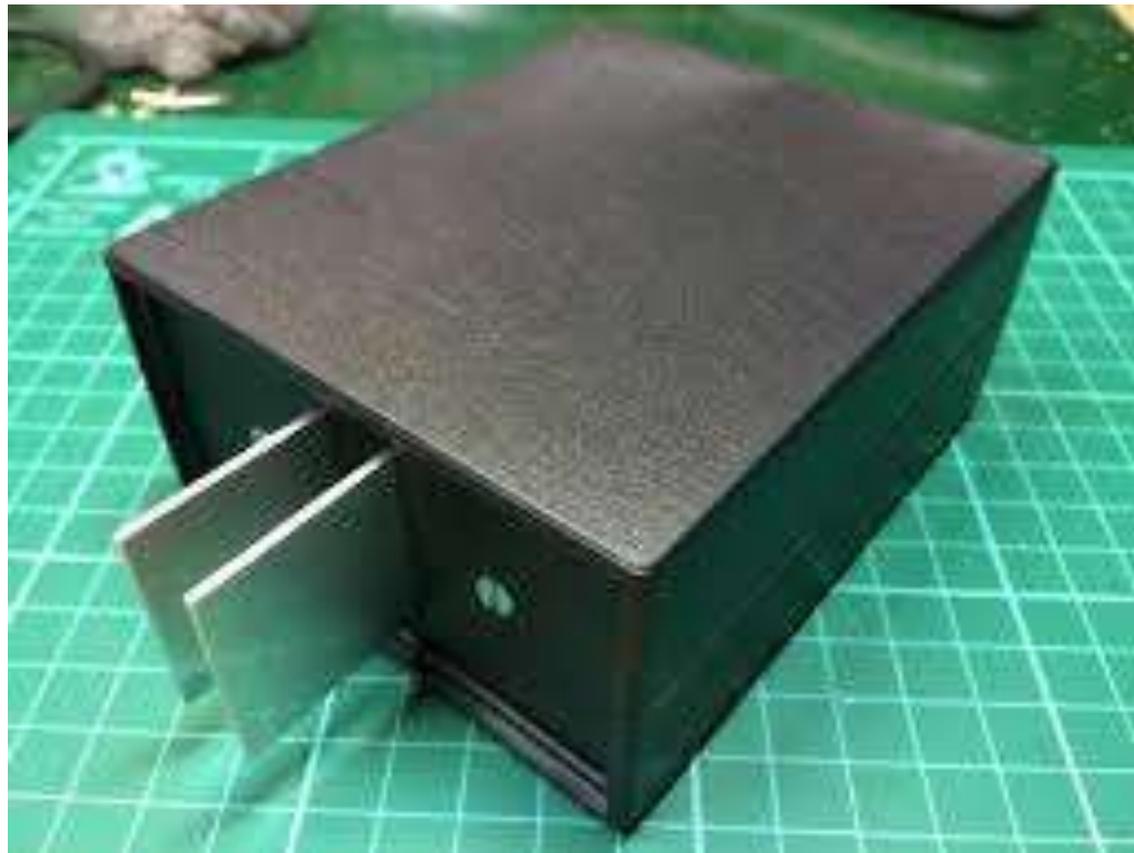
Bencher BY-1:



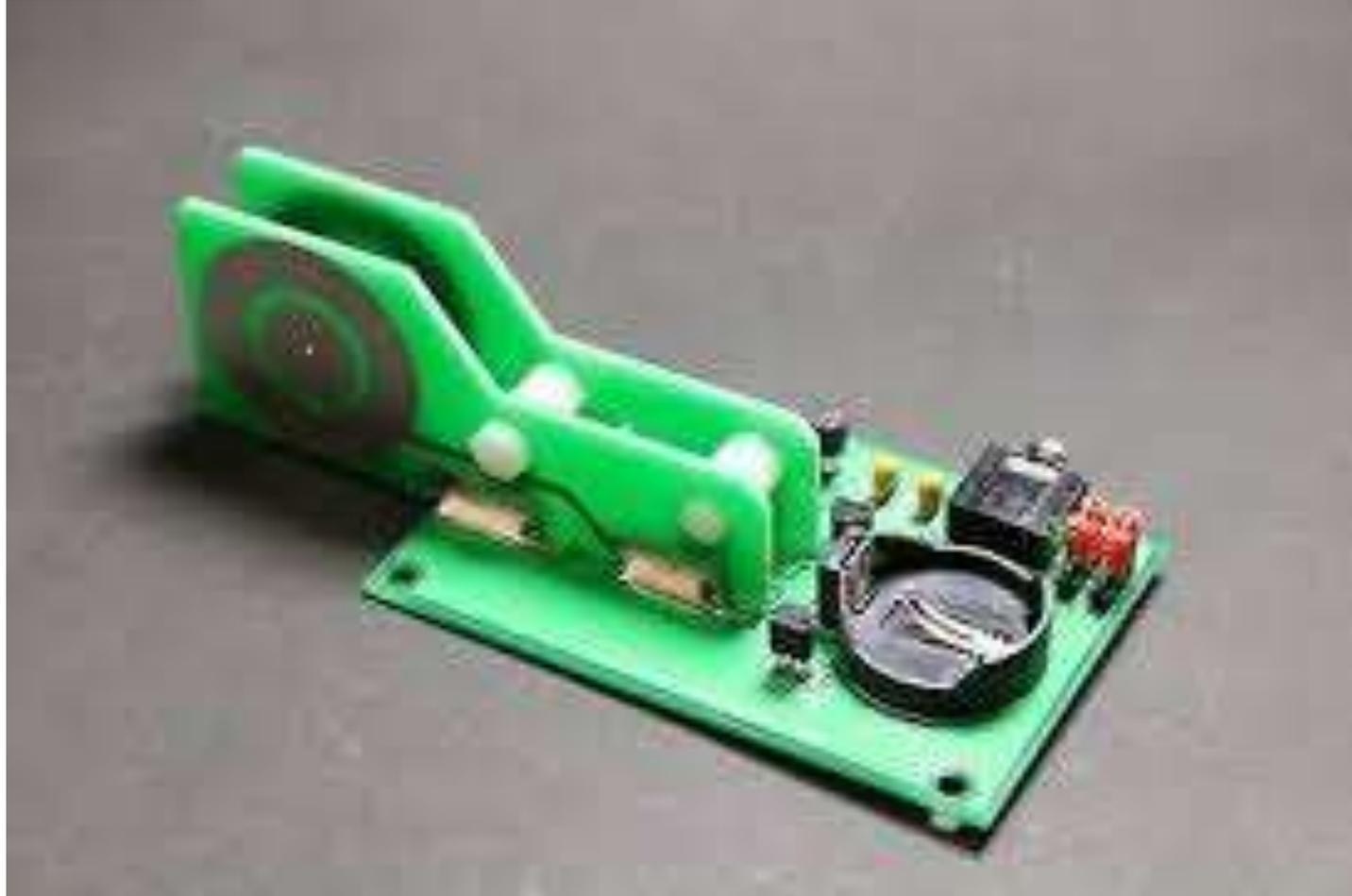
Magnetic IAMBIC Paddle:



Capacitive paddle:



Complete the circuit by touching key paddle:



Solid State twin lever paddle – 9A5N:



CW Key Suppliers

- Morse Express <http://www.morseexpress.com/>
- Vibroplex <https://www.vibroplex.com/>
- Begali Keys <http://www.i2rtf.com/index.html>
- 9A5N <http://www.9a5n.eu/index.html>
- American Morse Equipment <http://americanmorse.com/>

Keyer settings:

- Keyer Type (from Yaesu DX3000):
 - Off or straight key mode (use for straight key or cootie)
 - Bug
 - Elekey: dots and dashes are generated automatically when using a paddle
 - ACS: spacing between characters set to the same length as a dash (three dits in length)
- CW Weight – ratio of the length of a dah as compared to the length of a dit, typically set to 3:1.
- Keyer speed control
- Iambic mode:
 - Mode A: When set to mode A, when both paddles are squeezed, the keyer only completes the element being sent when the paddles are released
 - Mode B: When set to mode B, when both paddles have been squeezed, the keyer also sends the opposite element in addition to the one being sent when the paddles are released – an extra element.

Typical CW Settings:

- Full break-in or semi-break-in:
 - Full break-in (QSK) permits you to hear incoming signals between the dits and dahs of your transmission by switching between transmit and receive very rapidly
 - Semi-break-in is pseudo “vox” operation where the closure of the key engages the transmitter and the release will allow the receive to recover after a short delay. No signals are heard between dits and dahs (except if transmitting really slowly).
- CW pitch setting – this adjusts the center of the passband so that you set the pitch of the CW Carrier, typically rigs allow between 300 Hz and 1050 Hz. Mine is currently set at 600 Hz.
- Zero-beating – most modern rigs permit one touch zero-beating. This ensures that you and the other station are precisely on the same frequency. Most rigs also have a tuning offset indicator that can be used to zero-beat too.

Learning CW

- DO NOT:
 - Memorize a list of characters beside a list of the dot and dash combination used to form those characters
 - Create a look-up table and memorize it
 - Create visual mnemonics charts
 - Try to learn phrases that have the same rhythm (e.g., Q which is dah-dah-di-dah and God Save the Queen). This adds a step or two to recognizing and slows one down in learning how to copy the code at normal speeds
 - Start with trying to copy code at very slow speeds, planning on working to speed it up later. Slow code creates bad habits that must be broken later.
- Do
 - Learn the sound of the character at a speed that discourages counting dots and dashes, i.e., never slower than 18 wpm, preferably 20+ wpm.

Koch Method

- This involves learning two characters at full speed and once you are able to copy random groups of those two letters with 90% accuracy, adding a third letter and once you can copy random groups of those three at 90% accuracy, adding a fourth letter, and so on.

Farnsworth Method

As Thomas Edison said: “It is not the speed at which a letter is sounded that perplexes the learner, but the rapid succession in which they follow each other.”

When you start, always, always, have the character speed at 18 wpm to 20 wpm or higher. You can add space between the letters and the words as you build up speed in recognizing the letters. The goal is to shrink the extra space until the sending has no extra space (either between the letters or words).

Where to go to learn CW – on your own

- Learn CW Online: <https://lcwo.net/courseintro> Good all-purpose site for learning CW.
- Morse Code Trainer: <https://morsecode.scphillips.com/trainer.html> CWA method for Level 1.
- RufzXP: <http://www.rufzxp.net/> Great for practicing call signs.
- Morse Runner: <http://www.dxatlas.com/morserunner/> great for contest CW practice
- CWA practice files: <https://cwops.org/level-2-practice-files/> More interesting than the W1AW files.
- AA9PW's site: <http://aa9pw.com/morsecode/> Several practice tools. A way to practice QSOs.
- Morse Camp: <https://morse.camp/> Good practice for listening to words.
- CWGet: <https://www.dxsoft.com/en/products/cwget/> The best way to see if you are sending comprehensible code is to send and see if a decoder can understand your code.
- Quote of the day: <http://www.morseresource.com/podcasts.php> A way to have daily code copy practice, using a podcast that publishes daily.
- Listen to CNN, W1AW, or NN9u's practice tables: <http://cw.dimebank.com:8080/>

More ways to learn CW on your own

- **K7QO Code course** <https://www.kkn.net/~k7qo/>
- **AD0WE** <https://www.qrz.com/db/AD0WE> There are quite a few youtube videos at various speeds from 15 wpm to 50 wpm (e.g., state abbreviations, top 100 words, top 500 words, ESL words, QSO phrases, books, etc.). Much of what he has can be accessed in mp3 format by invitation (send him an email for the invite) through his DropBox.
- **Visual Farnsworth CW Trainer** <https://cwtrainer.loomcom.com/> (as Hackaday.com put it: “Learn Morse Code, Clockwork Orange Style”)

LCWO – in more depth

- Offers a combination of Koch and Farnsworth to learn the 40 key characters (letters, numbers, and punctuation)
- Morse Machine sends letters. You type them as heard and get a new one if you correctly copy the prior one.
- Code Groups allows you to drill one group at a time
- Plain text training sends text and scores you on how you copy that text
- Word training sends words (e.g., CW abbreviations, Q Codes, English words). You can limit the group of items sent, limit the length of what is sent, ask for simplified characters to be sent, and have the speed automatically increase each time you give a correct answer.
- You can set the character speed, the effective speed, the tone (in Hz) that is transmitted, and tell it to send in 5 letter groups or random group lengths

CW Elmers:

- CWops runs the CW Academy <https://cwops.org/cw-academy/cw-academy-options/>
- Long Island CW Club <https://longislandcwclub.org/>
- SFMARC (Samuel F. Morse Amateur Radio Club) <https://w6sfm.com/>

CW Academy

CW Academy:

- Three sessions of eight weeks each are offered each year (Jan.-Feb., April-May, Sept.-Oct.).
- Cost = FREE
- **Level 1 – Beginner skills – Limited or no prior experience with Morse Code Class Objectives:**
 - Learn Morse Code characters (letters, numbers, and some punctuation)
 - Learn to head copy and send Morse Code
 - Learn on-air protocols of a basic QSO
 - Use skills for on-air basic QSOs

CW Academy

- **Level 2 Prep** – Basic skills – Familiarity with Morse Code characters and desire to increase proficiency **Class Objectives:**
 - Increase head copy and send skills using Instant Character Recognition
 - Increase skills for on-air conversational QSOs
 - Introduction to contesting skills
- **Level 2** – Intermediate skills – Operating 11-15 wpm and desire to increase proficiency for contests, DX, and ragchews **Class Objectives:**
 - Increase copy and send skills by use of contesting tools
 - Increase head copy skills
 - Recognize words as sounds
 - Increase on-air experience with various types of QSOs

CW Academy

- Level 3 – Advanced skills – Operating 16-20 wpm and desire to increase proficiency for higher-speed on-air activity Class Objectives:
 - Increase head copy and send skills for higher-speed on-air activity
 - Increase on-air experience with various types of higher-speed QSOs
 - Increase contesting skills to 30+ wpm
 - Recognize phrases as sounds
 - Learn to copy from behind
 - Increase overall skills to become considered for CWops membership

CW Clubs

- FISTS - The International Morse Preservation Society <http://www.fists.org/>
- SKCC - Straight Key Century Club <https://www.skccgroup.com/>
- NAQCC - North American QRP CW Club <http://naqcc.info/>
- LIDS CW (The Less Involved Data Society) <http://lidscw.org/>
- CWops <https://cwops.org/>
- FOC - First Class CW Operators' Club <https://g4foc.org/>
- Instructional Clubs:
 - Long Island CW Club <https://longislandcwclub.org/>
 - Vienna Wireless Society CW Forums <https://viennawireless.net/wp/meetings/cw-forum/>

CW Nets

- North American QRP CW Club nets http://naqcc.info/cw_nets.html
- List of slow speed nets <http://ad4dx.com/gtn/indexCWSN.htm>
- How CW Nets are run:
 - Quick and Dirty CW Netiquette <https://www.qsl.net/n5lf/cw-nts.html>
 - NAQCC has procedures listed http://naqcc.info/cw_nets.html
 - Waterway Radio & Cruising Club CW Net <https://www.waterwayradio.net/cwnet.html>

CW NET PROCEDURES

- The NCS will generally begin the net by calling CQ ____ NET and giving his name and location and call for checkins - "QNI"
- Stations then check in by transmitting their call sign suffix and "/ST" if they are short time
- After taking a list of stations, the NCS will begin taking traffic from the listed stations by calling each in turn and sending "QRU"
- The station may respond with a short message to the NCS with a few general comments and stating "QTC for _____" if any traffic, or "QRU" if none
- The NCS may ask other stations to relay - "QSP" - and take other lists of checkins
- At the conclusion of the net, the NCS will generally list all the stations - "QNS" - and give a last call for "QNI" and "QTC"

CW NET ABBREVIATIONS AND Q-SIGNS:

AS - Stand By

C - Correct/Yes

CUL - see you later

EEE - doubling, AS

GA - go ahead

GG - going

GM - good morning

N - no

NCS - net control station

R - received ok (not yes)

R - decimal (with numbers)

T - zero (with numbers)

TMW - tomorrow

TT - that

TU - thank you

? - question (like QRL)

/ST - short timer

QNI - check into net

QNF - end of net

QRU - any traffic?

QNS - list net check-ins, or
I have no more traffic

QNZ - get on my freq.

QRX - I'll call back in x minutes

QRK - what's my readability?

QRZ - who is calling me?

QRL - I am busy

QSB - signal is fading in & out

QRS - send slower

QRQ - send faster

QSP - relay

QTC - message for call sign

QRT - closing station

Fun Rhythms in CW

- HiHi 
- 335 
- Best 73 
- TU2UUM 
- UU2 
- here her here hea 
- B7FG4 
- Bens Best Bent Wire 