Keys to Good Code

by Bob Shrader, W6BNB (Silent Key)
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Unlocking the secrets of sending precise Morse code.

Have you noticed how some operators send CW (Morse Code) so that every letter and word is unmistakable. while others send so many words that are hardly readable? There are good reasons for the latter difficulty and some simple remedies. But first. there are six devices to discuss. all of which have been or are being used to send CW.

These are the:

(1) straight key, or hand key;
(2) sideswiper key, cootie key, or double key;
(3) semiautomatic key, or bug:
(4) electronic keyer:
(5) Boehme-head type machines:and
(6) keyboards and computer circuitry.

All of these can be used to send perfect or nearly perfect code. but in many cases the code does not come out all that well. I've spent many years teaching hundreds of operators how to send both the International and the American Morse codes. and l hope the information in this article will help every reader improve his or her sending.

The straight key

The original and simplest key is the straight key. also known as a hand key. It is used to send at slower speeds usually in the five to l8 word-per-minute (wpm) range. With skilled operators. It can put out very good 20 to 25 wpm code, There were some very skilled operators in the past who could vibrate their hand and fingers in such away as to send at 35 wpm! However, there are few people—if anyone—who can do this anymore. A speed of 25 wpm is really pushing it with a straight key for most operators. Aside view of a basic straight key is shown in fig. 1. Pushing the knob down closes the keying contacts that are normally connected to the keying circuit in a transmitter, or possibly to a practice oscillator. The contact gap should be about 1 millimeter (nun), a little less than 1/16th of an inch. This is the key for anyone, beginner or old-timer. Who wants to learn to send code correctly. It was widely used by professional shipboard radio operators because it produced the easiest to copy CW through QRN or over long distances and because it provided no difficulty when the ship was rolling. It should be the first key to be mastered by anyone. because it is the best one with which to learn to hear and understand the extremely important requirement of proper spacing between dots and dashes. letters and words.

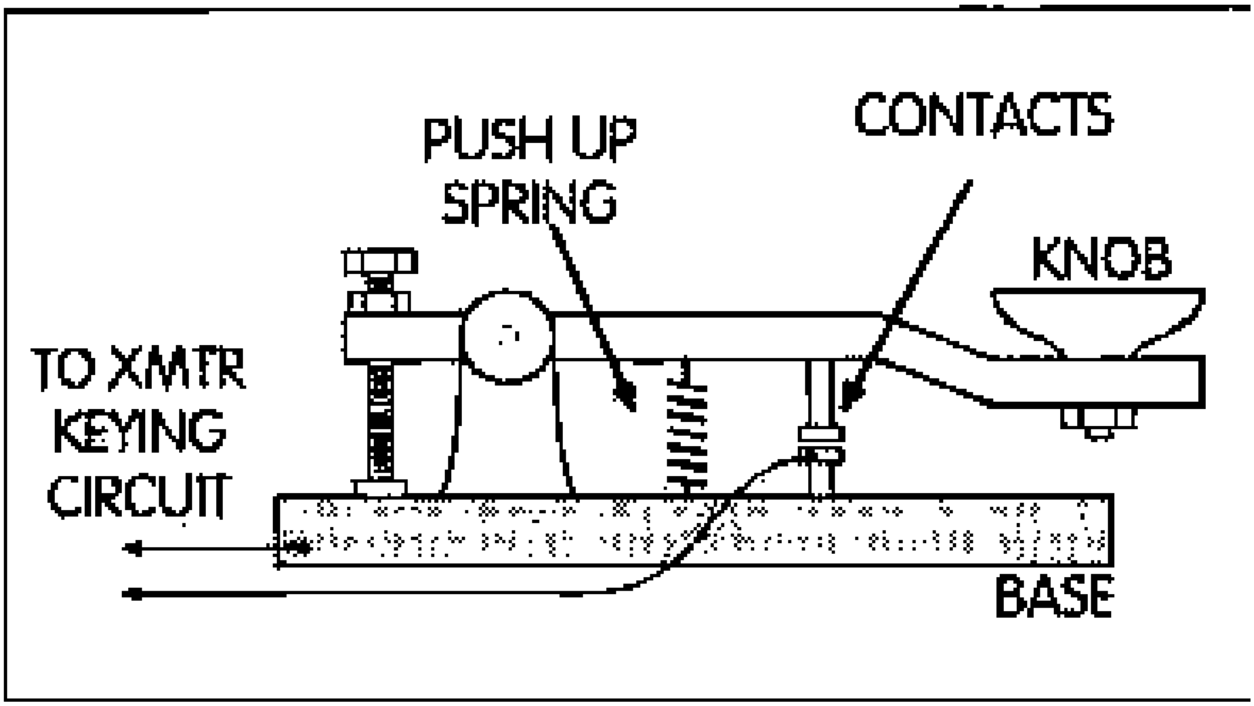

Fig. 1. Essentials of a straight key.

Spacing

If there is any one most important thing to learn about sending CW, it is proper spacing. There is probably only one chance in perhaps ten that operators (you?) space properly. If the proper spacing is not used, a receiving operator may not be able to guess what is being transmitted. There is nothing more discouraging to hear than a string of well-made letters. with no spacing to indicate where one word stops and another starts!

The theory of the timing of dots and dashes is simple enough. The length of a “dot“is the basic time element or “unit" of code sending. A “dash" is three units long. never two, although four or even more is quite readable to the human ear (long dashes can give the code its well-touted and interesting “swing." but computers hate it]. The spacing between a dot and a dash in a word is one unit long. The spacing between any two letters in a word is three units long. The spacing between any two words is seven units, Between the end of a word and a comma or period there should be three units, not seven units. Punctuation marks should be spaced as they would be when typing them on a keyboard. A good practice to develop a feeling for spacing for anyone trying to learn, or to improve sending, is to make a letter and then with your little finger tap the desktop before sending the next letter of that word. Between any two words, tap the finger twice on the desktop. Later, after you develop reasonable speed and ability, only tap the desktop between words. Eventually the sense of proper spacing will be ingrained in the subconscious and no more desktop ta p ping should be necessary, By that time, each letter should be made as one simple or complex sound. A 10-letter word should be heard as 10 simple or complex sounds, all forming one tied-together complex group of sounds, with no audible long (or lack of) spacing anywhere.

Using the straight key

A desirable way of using a straight key is to place the tip of the first finger on the key knob at a position of about 12 o’clock. with the thumb lightly touching the underside of the knob at about seven o‘clock. Flip the three other fingers downward about halfway to the desktop. This should close the key and open it again as the fingers swing back upward. Note that the wrist will push upward as the fingers go down. This is a correct way to make a dot. If the wrist goes down when the key goes down, it is the arm that is doing the keying. fingers are so much less tiring to use! [This is a major disputed opinion not shared by the English, Japanese, and Scandinavian “long lever, pump handle type key” users! - Ed.]

I once sent messages with a straight key for five hours with no stopping, from the Yangtze River to San Francisco, after my ship was bombed—but that's another story.)

Flip the fingers downward twice rapidly for two dots. Three times for three dots, etc. Practice making some eight-dot groups. All dots should come out with equal timing. Note the wrist: Make sure it goes up when the fingers go down. To make dashes, flip the fingers downward farther and hold the knob down for at least three times as long ask with dots. Practice making dashes in groups of eight or .mere. Note the wrist action with dashes—it should move farther upward than when making dots.
Practice making a string of 10 dot-dash (• −   • −   • −) groups strung together. Then practice making a string of 10 dash-dot (− − − −   − − − −   − − − −) groups strung together. The next practice is 10 dot-dot-dash-dot-dot-dash (• • − • • −   • • − • • −   • • − • • −) groups strung together. Then 10 “dash-dash-dot-dash-dash-dot” groups (− − • − − •   − − • − − •   − − • − − •).

This Exercise will provide practice in starting and making most letters and numbers.

I assume that you already knew the International Morse code. Here are some practice exercises for learning to send letters, words, sentences, and numbers. Concentrate particularly on spacing properly.

A QUICK BROWN FOX JUMPS
OVER THE LAZY DOG, 1234567890.
PACK MY BOX WITH FIVE
DOZEN LIQUOR JUGS, 0987654321.

These two lines contain all of the English letters and numbers, plus commas and periods. When you can send these correctly with proper spacing between letters: and words, with no hesitation anywhere (which takes quite a while), try sending them backward. When this can be done both forward and backward *without any errors*, you should be able to send fairly well with a straight key!

With a beginner the speed may be only five or six wpm.
With practice, the speed should come up to well over 10 wpm, and eventually to perhaps 16 to 20 wpm. To compute code speed, five normal letters plus a space is considered one word. If the standard word PARIS can be sent 10 times in 60 seconds, with proper spacing between words, the sending speed is 10 wpm.

The sideswiper key

This is a very old but simple type of a speed key first used by American Morse railroad telegraphers, probably sometime around the mid—1800s. It is far easier to operate than a straight key and with it the code can be sent about 50% faster. It is also called a “cootie key,” and sometimes a “double key,” because it works like two straight keys fastened bottom to bottom. The origin of the term cootie key seems to be unknown, but very possibly had some tie-in with the “bug” first used as a symbol en early-day Vibroplex semi-automatic keys.

A double key can be constructed by using two straight keys, fastened base to base. and mounted at 90° from their normal position. Another way to make a sideswiper key is to mount a three-inch piece of hacksaw blade solidly at one end, so the free end can swing back and forth between the fixed contacts at its near end. An insulating-material paddle should be fastened to the free end of the hacksaw blade. A top view of a basic sideswiper key is shown in Fig. 2.

If a metal base is used, the right-hand and left-hand contacts must be insulated from it. The gaps between both fixed contacts and the flexible arm should each be about one millimeter with the arm in its resting position.

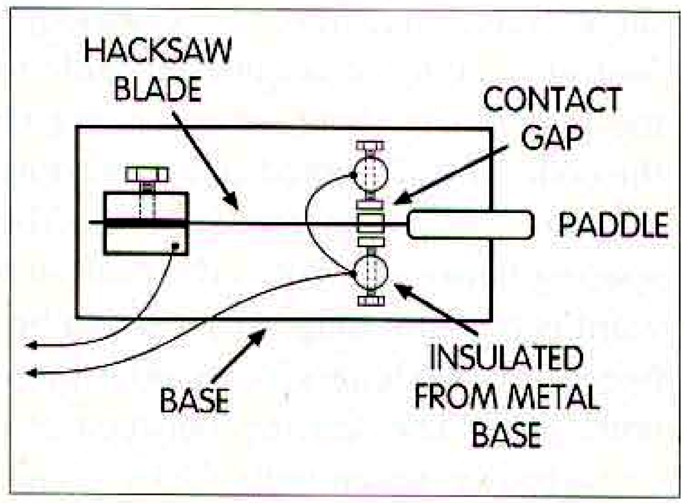

Fig. 2. Essentials of a sideswiper key.

To operate a sideswiper key, the first finger presses the paddle toward the thumb to make the flexible arm hit the stationary left contact. (Explanations are fer right-handed operators. Lefties will knew what they should do.) A quick motion in that direction makes a dot. If the contact is held at least three times longer, a dash is made. An appreciation of the difference in time between a dot and a dash learned with a straight key is important. The finger could be used to key dots and dashes the same way as is done with a straight key. but with a sideways instead of up-and-down motion.

Now comes the interesting part!

The thumb can press toward the first finger, moving the paddle to the right against the right-hand contact. If it makes only a quick movement. it will produce a dot if the contact is held three times as long it will make a dash. Code can also be sent horizontally with the thumb this way. Te send the letter “A" which is dot-dash, the first finger can make the dot and the thumb can immediately be pressed in the apposite direction to make the dash. However. if the thumb is used to make the dot. the first finger must immediately be pushed to the left to make the dash! Every letter or number can be started by either the thumb or the finger!It is up to the operator to be able to make the proper length dots and dashes whether they are being made by thumb or finger. Care must be taken to maintain all spacings properly. These are tricky keys to use. The straight key should be mastered first to ensure properly-learned spacings.

Sideswiper keys usually produce heavy data. If you like challenges. make yourself a sideswiper and try sending with it!

The semiautumatic key

Around the turn of the 20th century, the semiautomatic key, or bug. was developed. It has been made in many forms by many people and companies. Most of these keys are made to operate horizontally, but some operate vertically. Basically, a bug. which seems to be a generic term used today for semi-automatic keys, is somewhat like a sideswiper key. but is much better than the simple old cootie key. A top view of a basic bug is shown in Fig. 3.

When the first finger is pressed against the paddle, it can be worked the same as the first finger on a sideswiper key to make dashes. A horizontal form of straight key sending can also be produced with the first finger as with a cootie key. When the thumb is pressed against the paddle. it moves the near end of the main pivoted bar or shaft to the right. The far end of the bar moves to the left because of the pivot. Attached to the main bar on the far side of the pivot is a short piece of spring steel; attached to the end of that is the weighted vibrating rod. As the weighted rod vibrates from side to side. it makes and breaks a connection as its springed contact hits and rebounds from the fixed dot contact, thereby producing a series of dots. So, the thumb determines how many dots are made and the first finger must make all of the dashes. It is up to the operator to determine how long to make the dashes so that they are at least three times the length of the dots. It takes a trained ear to do this. an ear that is usually developed by properly-learned straight key operating.

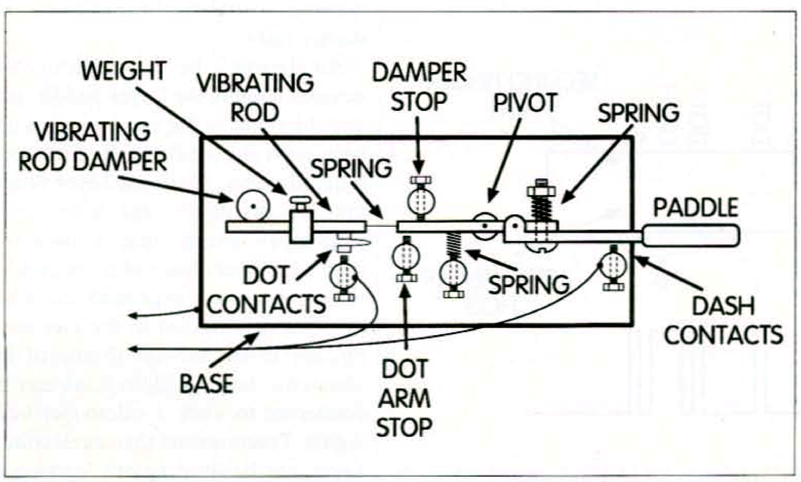

Fig. 3. Essentials of a semiautomatic key.

As long as receiving operators are copying by ear, longer-than-normal dashes will sound OK. but short dashes will produce a poor-sounding code. The spacing between the dash contacts, and the travel between the bar to the dot-stop when the paddle is pushed to the right, should both be about one millimeter. The thumb and finger should travel reasonable distances and strike the paddle fairly hard. {This was very important when bugs were used on ships during times when the seas were heavy and the ship was rolling.)

Where the movable weight is placed on the vibrating rod determines the speed of the rod vibrations and therefore the speed of the dots. The farther the weights are out toward the far end of the vibrating red, the slower the vibrations and the slower the dots.

You will find that if the stationary dot contact is moved up against the vibrating contact so that only about 10 to 12 dots are made before the dot contacts settle into a constant contact, the dots will he made at a desirable hearing length. Theoretically, the space between dots should equal the dot length.

However, for the receiving operator it is better if the dots are a little longer than the space between them. These are known as “heavy dots.” As mentioned before, “light dots” mean that the space is longer than the dots, resulting in poor-sounding code that may also be hard to read at a distance or under poor conditions, and may not be read properly by computer keyboards. I recommended that a bug not be tried before learning to space properly with a straight key first.

Most good hug operators send and receive in the 20 to 35 wpm range.

High-speed bug operators may get up into the 40 to 50 wpm range. Some may think they are operating their bugs correctly at these higher speeds, but if checked with “slip tape" (explained later), most will find that their spacing is almost always rather poor. If they were using an electronic keyer their letter spacings might be much better.

The electronic keyer

To improve on the vibrating dots of bugs, which usually have some variation between the first and last dots in letters like H or the numeral 5, there were many magnetic vibrator-type bugs built in the early decades [20th Century – Ed.] that worked fairly well. Around the 1950s, it was found that vacuum tube vibratory circuits could be used to produce perfect dots, spaces, and dashes. Then the small size and low voltages needed to operate transistors allowed them to take over the modern types of electronic keyers. There are a variety of these devices available today. Basic electronic keyers are improved semi-automatic keys. They use a square-wave electronic oscillator to produce perfect, constant~speed dots and spaces when the paddle is pushed by the thumb. They use the same oscillator with divide-down counter circuits to produce perfect, constant one-third-speed dashes (three times longer). The operator of this type of key does not have to worry about the length of dots or dashes—just the spacing between dots and dashes in letters, the spacing between letters, and the spacing between words. When the control is advanced to increase the oscillator frequency, it makes dots, spaces, and dashes faster.

An electronic keyer is basically two devices. One is the keyer paddle unit, and the other is the electronic circuits unit, with its oscillator, dividers, and other circuitry. The basic keyer paddle unit is essentially the same as a sideswiper, except that it uses two separate contact leads plus the paddle-arm lead (usually at ground potential], all of which are fed to the electronic circuits in the device. [Some of the electronic keyer paddle units can be connected to work a sideswiper key.)

Again, I recommend that an electronic keyer **not** be used before learning to operate a straight key properly. An electronic keyer can produce the perfect sending once produced only by the old-tithe commercial Boehme-head code machines.

The Boehrne-head-type machines

The Boehme-head and other similar machines were used from the 1920s to the 1960s to transmit perfect high-speed radio code. They were nicely machined little units about sis inches square and two inches thick, driven by an adjustable-speed electric motor.

Their punched waited-paper tapes were produced on a special typewriter-like keyboard tape-punching "perforator' machine. The letters punched into these transmitting tapes came out as properly spaced holes. Boehrne-head machines sent their perfect code at speeds determined by the driving motor's speed. Code at well over 100 wpm was easily produced.

The tapes they used had three sets of holes punched into them by the perforator. The center perforations were drive holes used to pull the tape along over two little pins that were alternately pushed up and pulled down against the moving tape from underneath. One pin was on one side of the center holes; the second was directly across the tape on the other side of the driving holes. When the first pin came to a punched hole, it would move up through its hole, starting an electrical connection. When the first pin went back down and the second pin pushed up, if this pin also found a hole in the tape it would move up through it, which shut the electric connection off, thereby keying a dot for the transmitter. If the first pin went up through a hole and started an electric connection, but the second pin found no hole, there was nothing to shutoff the keying circuit. When the first pin came up again, it could do nothing since the electric connection was still made. However, if the second pin came up again and found a hole to go through, it shut off the electric circuit. In this case, since there were three pin motions between the start and the stopping of the electric" circuit, it would key an electric circuit duration three times as long as was keyed for a dot, resulting in a dash being sent. Fig. 4(a) shows a five-letter word punched onto a Boehme-head tape.

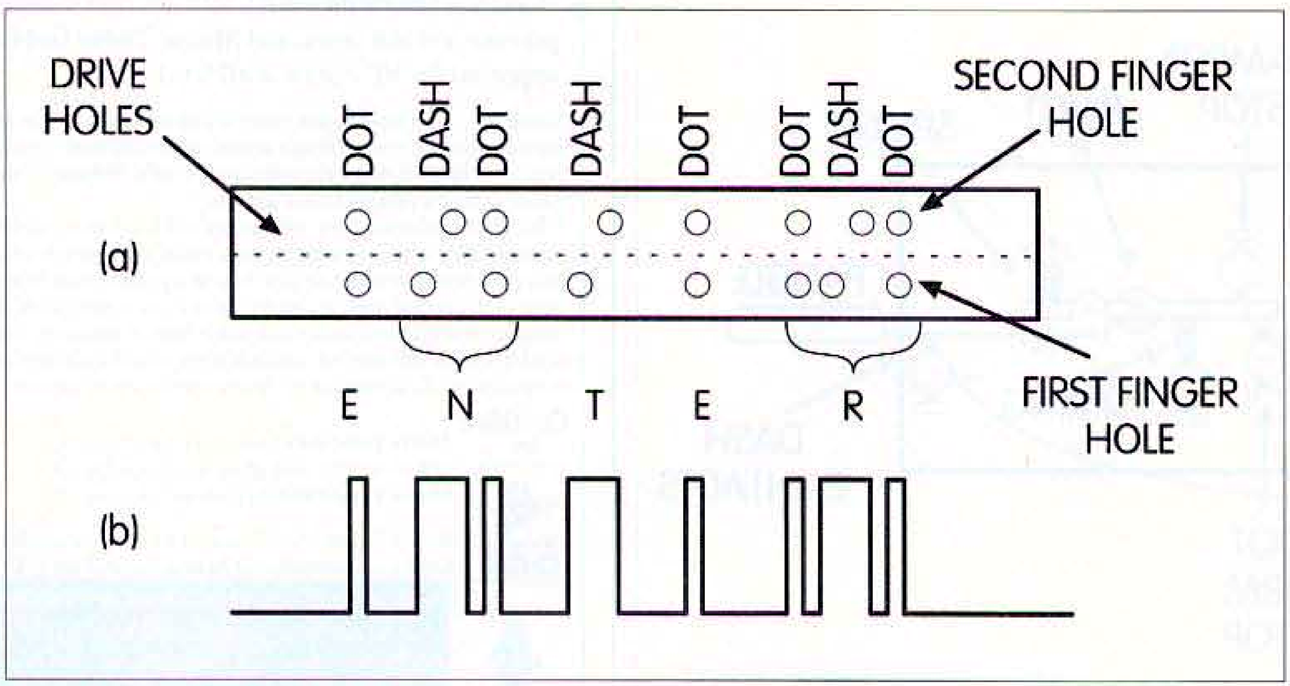

Fig. 4. *(a) "ENTER" punched onto a Boehme-head tape. (b) "ENTER" inked onto a slip tape.*

Tapes were usually punched and fed into a tall box. They were then either wound on a spool or were fed back into a second box so that the first punched material was available to feed into the Boehme-head machine. When slower-speed transmissions were to be made, the tapes could be punched by the operator and fed directly into the Boehme-head, although with a couple of feet of sag in the tape so that the Boehme-head machine would not get ahead of the tape puncher.

Slip-tape machines

Dot and dash tones received on radio receivers could be rectified, and the current developed by them could magnetically pull an inked pen up and down on a moving unwaxed paper “slip-tape" machine. With no signal being received, a straight line would be drawn by the pen along the bottom of the tape. When a dot was received, the ink pen was pulled up and then fell down at the end of the received dot, producing a narrow vertical pulse on the slip-tape, as shown in Fig. 4(b). When a dash was received, the line was pulled up but was held there for the duration of the received dash before dropping back down. Operators ran the slip-tape along the front of their typewriter at a speed controlled by a foot pedal, usually at greater than a did-wpm reading speed. The received letters and spaces were visually recognized and typed as letters and words on the typewriter keyboard.

Using a slip-tape device is probably the best way to check radio code sending. Any dot, dash, letter, or spacing made improperly is shown visually and permanently, allowing scrutiny and analysis. I have used such a device to graphically illustrate to students what they were doing wrong with their sending (but I also had to demonstrate to them what proper sending should look like)

Before computer-programmed keyboards were developed in the late 1970s, some Boehme-head machines were used on the amateur bands. Boehme-heads produced perfect code. but they used up an awful lot of paper tape!

The computer keyboard

When a computer keyboard (KB) operates with a Morse Code software program. plus a data controller unit to key the transmitter, it is capable of producing code transmissions as perfect as that from a Bochmc-head machine.

Besides not requiring the handling of dozens of yards of paper tape in one busy evening. a computer keyboard system has no moving parts other than the KB itself. and is soundless. The monitor screen of the computer shows the letter and words being typed and transmitted. The program can be adjusted to transmit Morse code at any speed desired, from very slow to very fast. With such systems in common use. amateurs can easily produce perfect code practice transmissions at high speed. As a result. some amateurs have learned to copy in their heads up to - and even above - 100 wpm! At such speeds they are probably learning to recognize many whole words, such as “the," as complex sounds instead of hearing their separate letters. They copy in their heads because trying to type out copy at speeds near 100 wpm is quite difficult.

I highly recommended that all CW operators learn to copy in their heads as soon as they find they can write down most of what they hear. It is really the only way to enjoy CW communicating. Those who talk down Morse code operating have probably never learned how much fun it can be when Morse code is copied properly. Commercial operators copy in their heads but always type several letters behind those being sent. This way. If the sending operator makes a mista e in sending, the error sign that is sent stops the receiving operator and the improper letter(s) is not typed onto the message blank. Copying behind by several letters is the sign of a good radio operator.

With a proper software program. computers can also be used to copy code off-the-air and display it on the screen. But the code must be sent almost perfectly. There is a little latitude in the length of dots.

spaces and dashes. but not a lot. If hand sending is not nearly perfect. the displayed copy may not be very good. With computerized transmission and reception. assuming no QRM or QRN, the displayed copy of previously typed information held in memory can be perfect to well over 100 wpm. Printouts may also be made of what is shown on the screen.
Few amateurs can handle a KB well enough to put out proper code at 50 to 100 wpm, so real-time transmissions made at such high speeds usually sound broken up to listeners. The overall transmission speed will be only the typist's typing speed. For a hunt-and-peck keyboard typist. 25 wpm is not an uncommon overall sending speed. although the letters might be set to transmit at 50 wpm or more. This would not be considered good communications transmitting—the result sounds jerky to any operator listening and trying to copy the transmission.

Very readable computer monitor displays can be produced by an electronic keyer. provided the transmitted dot, dash and inter-word spacings are good. Keyboard transmissions are expected to sound perfect. but if words are mistyped. are misspelled. or if they are broken up with unwanted spaces while desired keys are being looked for poor copy will result for radio operators who are trying to copy by ear or in their heads. To produce proper-sounding code. KB systems should not be set to transmit at a speed faster than thetypist can type well.

If KB transmission circuitry involves magnetic relays. there is the possibility that the transmitted dots will turn out to be quite light. resulting in less-than- desirable emissions. Some keyboard circuits have built-in “weight" controls by which the length of dots and dashes can be adjusted to reduce light dot transmissions.

Similar KB and computer equipment can be used to transmit and receive radio teletype information on the ham bands. However. many old-timers wax nostalgic for the clatter of the old ma chines and the yards of yellow paper or printed tape. that spewed out of the machines.

Some very new amateur transceivers have been developed that are operated by the keys on a KB coupled into the transceiver. There are no dials to rotate to select frequencies. All of the functions of sending and receiving CW, RTTY, packet. etc. are controlled either with the KB keys or with a mouse.
CW can be sent by using the keys on the KB. or by plugging in any type of key desired into the transceiver. Phone? Just plug a microphone into the transceiver.

Punctuation

Regular amateur CW communications use very few punctuation marks.

The exceptions to this are KB communications. Since all of the punctuation marks are available on all keyboards, they are becoming more common. In general. amateurs use BT as an end of a thought. or to indicate that the sending operator is thinking about what is going to be sent next. [The overlining of the BT is used here to mean that B and T are sent together as one character with no spacing between them. to sound like dahdidididah.) (Note the overline is NOT shown here as there is no font available.)

Some of the CW punctuation and operating signs heard on the bands are:

Period—	AAA
Comma—	MIM
Question mark—	IMI

Fraction bar or slash—	DN
Parenthesis—	Left KN
	Right KK
Dollar sign—	SK
Apostrophe—	WG
Error sign—	HH
End of a message_—	AR
End of a QSO—	SK
Wait—	AS
Start your transmitting—	K
Received OK—	R

The key to the key

Regardless of the type of device an amateur uses to produce CW. sending it correctly will always be a challenge.

One rule never changes. though: Practice makes perfect!

73

Bob Shrader, W6BNB
b. 20 October 1913
d. 11 April 2012 - aged 98 years. [See photo taken day before his death]

Bob starting radio pursuits at the age of 10 by building crystal radio sets, he began the pursuit of his lifelong passion for wireless radio communication and electronics which began while on a cruise to Hawaii with his parents in 1923. The ship's radio operator, a man from Sebastopol, Earl Wohler, invited Bob up to the ship's radio room. Thus began a lifelong friendship that lasted many decades until Earl's passing. Upon graduation from high school, Bob obtained his amateur radio license, W6BNB, and became a licensed commercial radio operator. This was at the height of the Great Depression. Jobs were scarce, but he was hired on as a shipboard radio-telegraph officer for the Dollar Lines, something unheard of for someone so young. Over the next several years he sailed around the world six times and trans-Pacific many more. Oh, the stories he has told about adventures in exotic ports-of-call all around the globe. In 1939 Bob became a deputy sheriff in Alameda County in charge of radiotelegraph operations. He married the only love of his life, Dorothy Fox, in 1941. At the beginning of World War II he began teaching radio and electronics to cadets on Treasure Island. He was assigned the rank of Lieutenant in the U.S. Maritime Service and they relocated to King's Point, NY, where he instructed cadets at the U.S. Merchant Marine Academy. He returned to his sheriff's position at the end of the war, but soon found his calling teaching electronics at Oakland Central Trade School, later known as Laney College. Bob turned his teaching materials into one of McGraw-Hill's top selling textbooks, "Electronic Communications", published in 1959 and in continuous production through edition 6 in 1991. This book was followed by many others, published in several languages. He retired and moved to Sebastopol in 1969 and built his home five miles west of town at the top of a hill among towering redwood groves. Bob continued authoring books and publishing numerous technical articles for national magazines. He joined the Freestone Fire Department in 1969 and quickly advanced from firefighter to Captain to Chief of the department. He orchestrated the merger of Freestone FD and Twin Hills FD in 1978 and served as President of the Twin Hills Executive Board after that. In 1997 he wrote and published "Fire Fighting, How It's Done". Bob was the founder and member of local, national and international radio organizations, and the recipient of awards and honors too numerous to list. At the age of 97 he researched and wrote "A Freestone Area Story". He was active and alert until his final day. The photo above was taken one day prior to his passing. You could see the sparkle in his eyes the moment he put on his old Merchant Marine officers cap. There will never be another like him. There will be no services.