**telegraphyandmorsecode**

**Telegraphy and Morse Code**

**A Data Communication Historical Series**

**By Bob Pollard**

**Telegraphy and the Morse code:**

An excerpt from Western Union’s historical records states the following:

“In 1832 Samuel F. B. Morse, assisted by Alfred Vail, conceived of the idea for an electromechanical telegraph, which he called the ‘Recording Telegraph.’ This commercial application of electricity was made tangible by their construction of a crude-working model in 1835-36.”

“The telegraph was further refined by Morse, Vail, and a colleague, Leonard Gale, into a working mechanical form in 1837. Electricity, provided by Joseph Henry's 1836 intensity batteries, was sent over a wire. The flow of electricity through the wire was interrupted for shorter or longer periods by holding down or releasing the key of the device. The resulting dots or dashes were recorded on a printer. In 1838 Morse perfected his sending and receiving code and organized a corporation, making Vail and Gale his partners.” End of quote.

Many individuals other than Morse were involved in inventing and developing the various telegraph devices, but this discussion focuses on Morse because the Morse code became the primary code, and secondary code, for message transmission for a long period of time.

A brief U.S. scenario of the original development of message communication systems follows.

In 1843 Morse received funds from Congress to set-up a demonstration line between Washington and Baltimore. After an unsuccessful attempt at laying underground cables Morse switched to the erection of telegraph poles and was more successful. On May 24, 1844, Morse in the U. S. Supreme Court Chambers in Washington sent by telegraph the oft-quoted message to his colleague Vail in Baltimore, "What hath God wrought!"

In 1845 Morse, after attracting a group of investors, formed the Magnetic Telegraph Company. Also, many other new Telegraph companies were formed because Morse sold licenses to any requesting new company.

The Magnetic Telegraph Company completed the first commercial telegraph line between Washington, D. C. and New York City in the spring of 1846. A short time later, F. O. J. Smith, one of the patent owners, built a line between New York City and Boston. At this time other telegraph systems based on rival technologies were also being built. Most systems embossed (dented) or printed on paper tape using dots and dashes. Some companies used the printing telegraph, a device invented by Royal E. House, which printed the messages on paper or tape in Roman letters.

By 1851 there were over fifty separate telegraph companies operating in the United States. The ‘New York and Mississippi Valley Printing Telegraph Company’ (NYMVPTC), later evolved into the Western Union Telegraph Company. Coordination between the rival companies was almost non-existent and in many cases exchange of messages was handled manually (hand carried).

In 1854 there were two rival systems of the NYMVPTC in the West. These two systems consisted of thirteen separate companies. All the companies in the five states north of the Ohio River were using Morse patents. This created a struggle between three separate entities, leading to an unreliable and inefficient telegraph service. The owners of these rival companies eventually decided to invest their money elsewhere and arrangements were made for the NYMVPTC to purchase their interests.

Hiram Sibley re-capitalized the company in 1854 under the same name ((NYMVPTC) and began a program of construction and acquisition. Sibley carried out the most important take-over when he negotiated the purchase of the Morse patent rights for the Mid-West, held by the Erie and Michigan Telegraph Company (EMTC).

In 1856 the company name was changed to the Western Union Telegraph Company, indicating the union of the previously mentioned Western lines into one system.

Between 1857 and 1861 similar consolidations of telegraph companies took place in other areas of the country so that most of the telegraph interests of the United States had merged into six systems.

* American Telegraph Company (covering the Atlantic and some Gulf States)
* Western Union Telegraph Company (covering states north of the Ohio River and parts of Iowa Kansas, Missouri, and Minnesota
* The New York Albany and Buffalo Electro-Magnetic Telegraph Company (covering New York State)
* The Atlantic and Ohio Telegraph Company (covering Pennsylvania)
* Illinois & Mississippi Telegraph Company (covering sections of Missouri, Iowa, and Illinois)
* New Orleans & Ohio Telegraph Company (covering the southern Mississippi Valley and the Southwest)

All these companies worked together in a mutual alliance, and other small companies cooperated with these six systems. By the time of the Civil War, there was a strong commercial incentive to construct a telegraph line across the western plains in order to link the two coasts of America. In 1860 the Pacific Telegraph Act, which authorized the taking of bids to construct a transcontinental line was passed. After the bid process closed two bidders dropped out and Western Union was the only bidder left and won the contract. The Pacific Telegraph Company was organized for the purpose of building the eastern section of the line.

Further consolidations took place over the next several years. Many companies merged into the American Telegraph Company. Several organizations were combined in 1864 under the name of the U. S. Telegraph Company. In 1866 the final consolidation took place, with Western Union exchanging stock for the stock of most of the other organizations. Later (1940’s) the Postal Telegraph Company and the Western Union Telegraph Company were the two remaining major message delivery companies and then they merged and only the Western Union Telegraph Company remained.

Progression to the Morse code and beyond:

The first major advancement in the telegraph system occurred around 1850 with the realization that the clicks of the telegraph recording instruments provided a sound pattern, understandable by the operators as coded dots and dashes. This allowed the operator to hear the message by ear and simultaneously write it down. This ability to hear and decipher the dots and dashes would later transform the telegraph into a versatile and fast system.

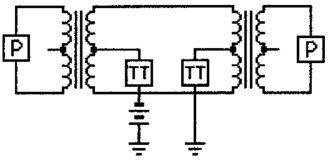
Morse's original register system, among other inventors’ devices, and prior to the Morse code system, had a stylus or pen (inker) attached to a receiving magnet that would move the stylus or pen to mark a moving paper strip. When a current was received over the circuit (Mark Signal) the stylus or pen marked the paper strip. The stylus lifted when no current was present (Space). The paper strip was pulled through the register (recorder) by mechanical clockworks. The receiving operator had to decipher the recorded message (indentations) and write it down on a telegram form. Later registers printed the dots and dashes. When it was found easier to decode directly from the sound of the register, the key and sounder device were developed. It was less work to operate a sending Key than to handle the clumsy set of notched transmitting blocks required for transmitting an indented or printed message. Also, fewer operators were required.

During this same period a Telegraph machine invented by Buckingham printed received messages in plain Roman letters quickly and legibly on a message blank, and ready for delivery.

Duplex Telegraphy, 1871-72, was invented by the president of the Franklin Telegraph Company. Unable to sell his invention to his own company he sold the invention to Western Union. Utilizing this invention, two messages could be sent over a single wire simultaneously.

Clarification: Simplex, using a single line, can indicate transmission in one direction only or as illustrated below using telephone lines, a half-duplex operation. Half Duplex, single line, allows transmission in both directions, but not simultaneously. Duplex (Full Duplex), depending on the equipment may use one line or two lines; allows simultaneous transmission in both directions.

Below is an example of a simplex telegraph circuit on a metallic telephone circuit (P) using repeating coils. These coils are 1:1 transformers with center taps. The Teletypewriters could be connected in a normal ground-return circuit between the center taps at the two ends (send right – receive left in the diagram). They do not create a disturbance on the telephone circuit and the telegraph circuit would have the two-line wires in parallel, decreasing its resistance. The proper operation of this circuit depended on balance between the pair of wires. Lack of balance would cause interference between the telephone circuit and the telegraph circuit. The telephone line wires had to be transposed at various intervals to reduce inductive crosstalk.



A little note of interest: Thomas Edison's Quadruplex (interleaving) invention allowed four messages to be sent over the same wire simultaneously, two in each direction. This was taken from an English automatic signaling arrangement. Baudot invented a similar device.

All data (message) communication during the 1800’s used either underground cables or overhead wires (land-lines) on poles for transmitting information. The overhead wires were the most common, especially for long distances. Direct Current (DC) was used for the power source. In the beginning batteries were used locally and for short distances. Later DC power generators were used to provide the power, which accommodated greater distances between connected users. Alternating Current (AC) or analog signals were used for voice signal purposes with the invention of the telephone. Later analog signaling would be used for data (message) communications, with the invention of the ‘Carrier’ system in the mid 1930’s.

Morse code:

As mentioned earlier the first major advancement in the telegraph system occurred around 1850 with the realization that the clicks of the recording instrument portrayed a sound pattern, understandable by the operators as dots and dashes. This allowed the operator to hear the message by ear and simultaneously write it down.

During the 1850’s one might state that actual high-speed message or data transmission began with the invention of Morse code by Samuel Morse and this medium in some form has been in use since the 1850's. Later the Morse code was also referred to as the American Morse code. A Key and Sounder mechanism was used to create dots and dashes, with a unique combination assigned to each alpha, numeric and special character. The key, operated by hand, created an open or closed-circuit condition, and this allowed the operator to create a dot or dash and the necessary character dot and dash combinations. Closing the key for an instant and releasing created a dot and holding the key closed for a longer period before releasing created the dash. In the Morse code there is a short and long dash and a pause between dots that is used in order to accommodate all the alphanumeric and special characters. Unit (dot/dash) length and timing, and timing of character length, space between components (dot/dashes) and between characters was taken into consideration in order to establish standards.

An example ‘excerpt’ from these standards and tables reads as follows:

“If the duration of a dot is taken to be one unit than that of a dash is three units. The space between the components of one character is one unit, between characters is three units and between words seven units. To indicate that a mistake has been made and for the receiver to delete the last word send: ........ (Eight consecutive dot pulses)”



Key Sounder

The transmission of information was accomplished electrically through the use of DC (Direct current) voltage and mostly carried on above ground iron/copper transmission lines (land-lines), usually installed on telegraph poles along railway lines. Two basic electrical functions were used.

One was the mark-space operation using a voltage level for a mark condition and an open line condition for the space. Closing the key created a current flow, a mark condition (positive voltage), and opening the key created an open line condition, no current flow (no voltage).

The second type of operation, polar, was more efficient and could be used over longer distances. The polar form of operation used a positive voltage for the mark condition and a negative voltage of the same value for the space condition. The necessary Direct Current (DC) voltage level assigned to a circuit between two points had to be high enough to accommodate the circuit resistance and weather conditions, in addition to other factors. By the early 20th century, most telegraph lines were powered by motor-generators, although in many cases the gravity battery continued to be used to power the local circuit. This practice continued into the 1940s.

As the distance between transmitting and receiving points increased beyond two to three hundred miles, and depending on external conditions, it was necessary to use relays or repeaters that could take a weak signal and restore it to a normal voltage level. The repeater was a device that could read the decreased voltage signal through a set of coils and forward the restored signal and voltage through a set of contacts operated by the energized coils. The contacts were powered by the required voltage and duplicated the original dots and dashes.

Also, the local Sounder was not usually placed in the telegraph main line (circuit), since its resistance was too high. Instead, a Line Relay (low resistance), which allowed for connection of the local Sounder, would be inserted in the line.

Many offices (cities) could be connected to a particular line in series, either on a half-duplex circuit or full duplex line, which allowed communication in both directions simultaneously. Each point could also act as a relay station to the next point on the line. When a particular operator on the line sent a message, it was received by all offices connected to the line. Therefore, it was necessary to have ‘call letters’ representing each office so the appropriate office could respond, connect and record the message for delivery. All other offices could ignore the message.

A mainline calling sounder, via a main line relay, was used to monitor the traffic on the line. If the office call was heard on the calling sounder, a cordless jack box, or some other method, could be used to connect the line to the local sounder. In the jack box the desired line was selected by inserting a plug into the appropriate jack. Contacts inside the jack box connected the mainline to the local sounder. The plug was a brass rod. No wires or cords were required, thus the name cordless jack box. The pictured box below handled 3 telegraph lines.



Current flow (closed line) caused the sounder mechanism (electric coil/magnet activated) to close and click and current flow removed caused the sounder to release and click. A dot would occur rapidly, two quick clicks, and a dash would pause between clicks, which could be a short or long period between clicks since there is a short or long dash. Each character (alphanumeric) sent was composed of a combination of dots and dashes. The Morse (telegraph) operators became very efficient at using the Morse code and this all occurred at a high rate of speed.

The Key was the transmission device and the Sounder was the receiving device. In a serial operation, the Sounder worked at both the transmitting and receiving location during message transmission. In a duplex operation the key could be used without the sounder clicking, but if necessary, a sounder could be connected to the send side to allow the operator to hear the message transmission.

In the late 1800s the Morse code operators started using a spring-loaded key referred to as a ‘bug’, which allowed a much faster operation. This device used a horizontal movement instead of the vertical movement of the original key. When the handle was held to one side it would continuously send dots until released. When held momentarily in the opposite direction a dash would be transmitted.



An Early production Martin Vibroplex; referred to as the ‘Bug’ by many individuals

The Morse code Telegraph system could be called the first message and/or data communications network. The transmission lines (circuits) were installed between most cities (towns) where a Post Office or a train station existed, which made it possible to send messages between all areas throughout the United States. Of course, not all cities (towns) were interconnected to each other so in many cases the message would be manually relayed from city to city until it reached the final destination. Some private companies, in addition to the Telegraph companies, also established their own Telegraph systems using both private and public leased lines. In addition, a person could climb one of the transmission line poles and connect up a portable telegraph unit for sending and receiving the Morse code. Although in many cases these devices were receive only.

The early Morse code, using physical overhead transmission lines was well suited for this form of communication, but the clicking sounds could not easily be adapted for radio telegraphic communication due to the embedded spaces, which were actually an integral part of several letters.

For instance, the letter o consisted of a dot-pause-dot. Since radio transmission was sent as a series of tones and did not use clicking sounds the space had no significant value. In order to solve this problem, the original Morse code was replaced in England by a similar code, which eliminated all the embedded spaces and long dashes. For instance, the letter ‘o’ became dash-dash-dash. This new code was called the ‘Continental or International Morse code’ and became the universal standard for European Radio Telegraph and land line telegraph communications. It was only in America that the original Morse code continued to be used by railroad and inter-city land-line telegraph operators through the 1950's, using the key and sounder / echoing relay.

Morse code table:

The following table (list) illustrates the dot and dashes equivalents found in the Original Morse code (American Morse code), and the Continental / International code. All alpha characters were in upper case.

Alphanumeric MORSE CODE: DOT = \* DASH = - LONG DASH = ---- PAUSE = ^

CONTINENTAL CODE Character:

A \* - \* -

B - \* \* \* - \* \* \*

C \* \* ^ \* - \* - \*

D - \* \* - \* \*

E \* \*

F \* - \* \* \* - \*

G - - \* - - \*

H \* \* \* \* \* \* \* \*

I \* \* \* \*

J - \* - \* \* - - -

K - \* - - \* -

L ---- \* - \* \*

M - - - -

N - \* - \*

O \* ^ \* - - -

P \* \* \* \* \* \* - - \*

Q \* \* - \* - - \* -

R \* ^ \* \* \* - \*

S \* \* \* \* \* \*

T - -

U \* \* - \* \* -

V \* \* \* - \* \* \* -

W \* - - \* - -

X \* - \* \* - \* \* -

Y \* \* ^ \* \* - \* - -

Z \* \* \* ^ \* - - \* \*

1 \* - - \* \* - - - -

2 \* \* - \* \* \* \* - - -

3 \* \* \* - \* \* \* \* - -

4 \* \* \* \* - \* \* \* \* -

5 - - - \* \* \* \* \*

6 \* \* \* \* \* \* - \* \* \* \*

7 - - \* \* - - \* \* \*

8 - \* \* \* \* - - - \* \*

9 - \* \* - - - - - \*

0 ------ - - - - -

Period \* \* - - \* \* \* - \* - \* -

Comma \* - \* - - - \* \* - -

Question - \* \* - \* \* \* - - \* \*