Overland Telegraph
150th Anniversary
1872-2022

OT-150 TELEGRAMS **No 9**

How Did the Telegraph Work?

Despite its massive size and monumental impact, the Overland Telegraph is as about as simple an electrical circuit as you can get: some batteries, some switches (telegraph keys), some relays, and some wire – lots of wire! That it worked as well as it did is a tribute to the ingenuity of its inventors and the skills of its operators.

Warning: contains technical explanations

A **Telegraph** is a system for sending messages over long distances. **An electric telegraph** was one of the first practical uses of electricity. To explain how it works, you need to understand a few simple things about electricity. If you do, read on: if you don't, the story alongside might help.

An electric telegraph is a simple electrical circuit. Two stations are connected by a wire. An operator at one station operates an on/off switch – called a **telegraph key** -- to start and stop a flow of current along the wire; the operator at the other end detects the starting and stopping.

In the early days of electric telegraphy, many people came up with different methods to send messages along a wire. A ship's telegraph, for example, enables the captain on the bridge to send one of a small set of signals to the engine room: stop, slow, half, full. However, a really useful telegraph would be able to send text messages and the first of this type were **needle** telegraphs: the electromagnet would move a needle to point to a letter on a dial. However, to point to all the letters of the alphabet required up to five needles and each needle needed its own wire. The first commercial five-needle system was installed by a railway company in England in 1838. Then they realised they could use just two needles to represent letters by a code and eventually only one. This code had to be learned by people who became the first **telegraph operators**: what the company saved in only having to install one wire more than paid for their training.[1]

Mention telegraph code and most people think of **Samuel Morse** and his dots and dashes. Morse didn't invent an electric telegraph: his idea was to use the electric current in a telegraph line not to move a needle but to move a pen which made a mark on a piece of paper. The sequence of marks and the spaces between them represented letters of the alphabet according to a code devised by Morse.

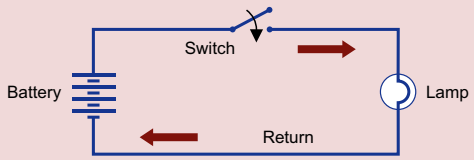
But what he did invent was the "local circuit". Because of resistance in the wire, the current at the end of a long telegraph line was quite weak. However, Morse realised it was enough to operate a relay in the receiving station which controlled the "local" circuit with its own battery. Prescott described it like this in 1866:

> The effect of this combination of circuits is to enable a weak or exhausted current to bring into action and substitute for itself a fresh and powerful one.[2]

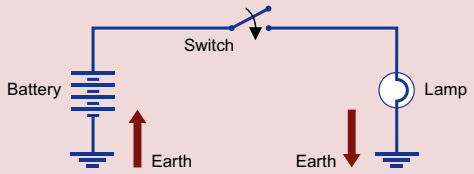
What Morse didn't realise was that, over time, the telegraph operators would learn to recognise the sound made by the pen device as it recorded the signals and

Electrical Circuits

A simple electrical circuit looks like this: a battery (a source of voltage or electrical pressure), a switch, a device (eg, a lamp), and wiring. When the switch is closed, electric current flows around the circuit and the lamp lights up. This circuit needs two wires: one from the battery through the switch to the lamp, and one returning to the battery to complete the circuit.



Another type of circuit called an "earth return" needs only one wire. One end of the battery is connected to the earth and one end of the device is connected to the earth. Now, when the switch is closed, the battery draws current from the earth and "pumps" it into the circuit: the lamp lights up as current flows back into the earth, effectively returning it and completing the circuit.



The first circuit is like a recirculating system in an aquarium whereas the "earth return" circuit is like pumping water from a dam. When you open the tap (equivalent to closing the switch), water flows onto your garden. It will keep flowing because water coming from somewhere else keeps the dam full to supply the pump.

One more explanation: scientists observed that, when an electric current flows through a wire , a magnetic field is produced around it. If you wind the wire into a coil, the magnetic field from the same current is stronger because the fields in each turn of the coil reinforce one another. And if you put an iron core inside the coil, the magnetic field is stronger again – you've made an **electromagnet**. With lots of turns in the coil and an iron core, a relatively small current can produce a very strong electromagnet.

An electromagnet can be used to operate a type of switch called a relay: the electromagnet is in one circuit, the switch is in another. A spring holds the switch open (or closed – it can work both ways) until a current flows in the electromagnet: the switch is then pulled closed (or open) as long as the current is flowing. When the current stops, the spring pulls the switch open (or closed) again.

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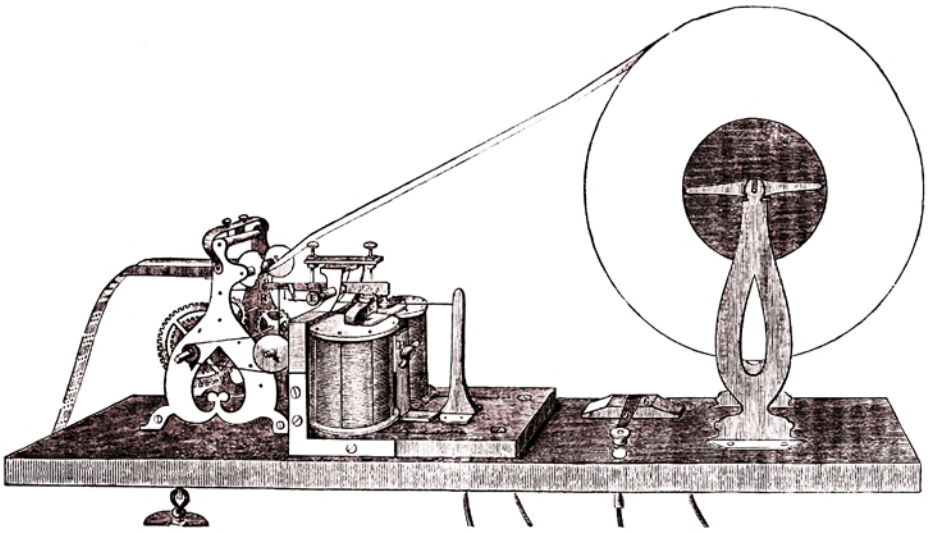

Samuel Morse's first telegraph receiver: a pen made marks on a paper tape drawn under it by a clockwork mechanism [Prescott, 1866, p423]

write them down: not only that but, because they knew their Morse Code, they could write down the actual letters! At many stations, the pen recorder was replaced with a type of relay called a **sounder** designed to make a distinctive sound as it opened and closed; it was also housed in a sounding box to ensure that operators could hear its clicks and clacks with clarity.

The first telegraph line in the United States was completed in 1844 and Morse sent his famous message "What hath God wrought" on 24 May. By the time Australia had its first telegraph line installed, the Morse system was well established. Samuel McGowan, an Irish-born Canadian engineer who had worked with Morse, came to Victoria in 1853 intending to set up his own private telegraph company. Instead, the Government decided to put all telegraph lines under its control and appointed McGowan as the first superintendent of the Electric Telegraph Department. Australia's first telegraph line, between Melbourne and the port city of Williamstown, opened in March 1854.[3]

In South Australia, the Government had appointed Charles Todd as superintendent of its Telegraph Department. The newly-married Todd and his wife Alice arrived in Adelaide on November 1855. Todd brought with him thousands of cases of material and equipment to build a telegraph line between Adelaide and Port Adelaide. (After waiting months for a ship to arrive from England, Adelaidians could wait no longer and wanted news telegraphed from the port to the city straight away.) Todd also brought with him an assistant, Edward Cracknell, and was prepared to train local operators. Todd's line opened for business on 18 February 1856.[4]

The technology he had chosen was **Henley's Magnetic Telegraph**. This was a type of needle telegraph but, instead of having a key and a battery, the operator generated a pulse of electric current by twisting a handle to move a coil of wire through the field of a permanent magnet. (Just as an electric current and a coil could produce a magnetic field, a magnetic field and a coil can produce an electric current. It's the basic principle of electric generation and it's called **induction**: you can look it up if you'd like to know more.)

The SA Government were well aware of the potential of the telegraph and, as soon as Todd had the Port Adelaide line working, they sent him to Melbourne to explore the possibilities of connecting the two colonies. Todd and McGowan conferred and, in a most significant step, Todd agreed that the Morse system was the better choice. In turn this system was adopted by the other colonies and in this way Australia had a uniform telegraph system, unlike the railways with their different gauges! The Intercolonial Telegraph between South Australia and Victoria was formally opened on 21 July 1858.[5]

However, there was more than one Morse Code -- which became an issue when Western Australia was finally connected by telegraph to the other colonies on 9 December 1877 (see **More on Morse Code,** page 3).

By 1867,[6] Tasmania was connected to Victoria, Victoria was connected to New South Wales, and New South Wales was connected to both Queensland and South Australia. With these colonies connected, the next step was the **Overland Telegraph** which connected the hub at Adelaide with the overseas cable which came ashore at Darwin (then called Port Darwin).

The technology of Australia's early telegraphs was the **Morse NC (Normally Closed) Earth Return system**. "Earth Return" has been explained on page 1. "Normally Closed" means that the telegraph stations along the line have their telegraph keys latched in the **closed** position. The line is continuous and a current flows along it. The batteries supplying the current were Meidinger Cells and only produced an output of 120 volts. The Overland Telegraph Line was 3200 kilometres long, built for the most part with No 8 galvanised iron wire which would be perfectly at home in a fence, and therefore had significant resistance. Nevertheless there was enough current flowing through the relays at each station to hold the switch in the local circuit open.

When an operator wanted to send a message, he opened his key: this stopped the flow of current and the switch in each local circuit was pulled closed by its spring. Current now flowed in this circuit and operated the sounder with a "click". When the operator closed his key, the current in the line was restored, the relay at each station was pulled open again, and the sounder in the local circuit made a "clack". What is interesting for non-telegraphers trying to understand how this works is that the telegraph operator is listening to **the gap between the click and clack sounds**: a short gap is a dot and a long gap is a dash. Most of us tend to think of Morse Code being sent by radio operators where it's **the length of the tone sound** that's significant: a short signal (a "dit") is a dot and a long signal (a "dah") is a dash.

With a number of stations along the Line, each operator would hear the click: how would he know which station was the intended recipient? Today, we start an email with To and From and messages on the telegraph system were similarly addressed. Each station had its own address, usually consisting of two letters: Adelaide was A and Port Darwin was PD. A message from Adelaide intended for Port Darwin would start with a call, "PD, PD, PD, A"; the operator at Port Darwin would then confirm he is ready to receive the message by sending "PD, GA" (go ahead). Other operators along the Line could then ignore the message (or choose to listen in). There were various other checks to make sure the message had been received correctly; for example, when the sender had finished sending three messages, he would sign off with "3, NM" (no more) and the receiver would confirm he'd received three messages by sending back "3, OK". (There were a number of other telegraphy protocols to ensure accuracy but this should give you some appreciation of how it worked.)

The Overland Telegraph Line connected Port Augusta and Port Darwin. There was already a line from Adelaide to Port Augusta via Clare and Melrose on the eastern side of the Flinders Ranges but a second line dedicated to OLT messages was completed on 12 July 1872.[7] Along the line were repeater stations at about 300 kilometre intervals. However, on a good day when there was little atmospheric disturbance, the insulators were clean so that there was little leakage across them, and the joins in the line were in perfect condition, it was possible to send messages directly from Adelaide to Darwin and back. A group of Adelaide newspaper editors witnessed this on Friday 23 August 1872, the day after Robert Patterson made the final join at Frew Ponds. They gathered in the Telegraph Room and the *Register* provided this account:

The Working of the Port Darwin Telegraph.— Through the courtesy of Mr. Cunningham, the Acting Superintendent of Telegraphs, we had on Friday, August 23, an opportunity of observing the wonderful steadiness and precision with which the Adelaide and Port Darwin telegraph line works. Shortly after 3 o'clock we repaired, by Mr. Cunningham's invitation, to the operating-room, where one of Morse's self-registering instruments was placed in direct communication with Port Darwin. The length of the wire is computed at nearly 2,200 miles, so that to complete the circuit of the magnetic current a distance of something like 4,400 miles — more than half the diameter of the globe — had to be traversed. Nevertheless the batteries worked as freely, as powerfully, and as instantaneously as if they were simply telegraphing to Port Adelaide. For upwards of half an hour a lively conversation was maintained with the Port Darwin operator and with most of the leading men of that sparsely-inhabited community, who to the number of nearly half a dozen speedily flocked to the scene of action. The state of the weather was of course the first topic of discussion, but the conversation speedily diverged into such friendly chit-chat as might pass between two persons meeting in the street. We need scarcely add that it was 'not intended for publication.' In every instance, either of sending or receiving a message, we were gratified to observe that the instrument worked perfectly. From the close of a question from Adelaide to the first preliminary signal of the reply from Port Darwin the

A telegraph sounder (left) and key displayed in the Bennington Museum, Vermont, USA [Photo: Daderot]

interval was scarcely appreciable. The reader who has seen one of the instruments at work will best appreciate this when we say that the travelling paper slip which receives the impression both of the question and reply showed a blank space, often considerably less than an inch in length, between the last sign of the question and the first indication of the answer. Among other questions, the Port Darwin operator was asked what o'clock it was, and whether he received the time signal dispatched daily at 1 o'clock from the Adelaide Office to all the South Australian Stations. He replied that the signal duly reached him, and that the then time was twenty-one minutes past 3. The transmission of the whole of this question and answer occupied from first to last exactly twelve seconds. Subsequently Mr. Cunningham spoke [to] other stations, including Alice Springs, the Peake, and Beltana, when the various styles of manipulation by the different operators were distinctly perceptible even to our untrained ears. A skilled operator can in this way recognise the person who is working the instrument even at a distance of 2,000 miles as easily as he would identify a familiar handwriting. In conclusion, we would remind our readers that the experience we have thus recorded was not at an exceptional time carefully picked out when the line was in unusually good order. It was within twenty-six hours of the first completion of the connection, and we imagine there is no reason to suppose that the line will be found, as a rule to work less freely in the future. So satisfactory a result must be eminently gratifying to Mr. Todd as it is equally creditable to the care and skill of those who have so successfully carried out this great work under his instructions. Although we have on a previous occasion fully described the interior of the Postal and Telegraph Offices, we cannot close this notice without a word in praise of the noble proportions and admirable arrangements of the operating-room. A more perfect development of the value of skilful organization and contrivance it would be difficult to find.

SA Register, 24 August 1872, page 5c

More on Morse Code

A **coded** message uses one thing to represent another. In 1835, Morse decided to use numbers to represent words and he listed these in a "telegraphic dictionary" or code book: for example, "Successful experiment with telegraph" was "215 36 2 58".[8] This was a type of **encryption** and all

Operators at the Eucla Telegraph Station on 27 October 1902: note the hole in the partition (arrow) through which messages were passed [State Library SA B54057/12]

senders and receivers, of course, had have to have copies of the same dictionary.

Alfred Vail, who worked with Morse in developing and commercialising the telegraph, expanded this idea and the result was **American Morse Code** which used a sequence of dots and dashes to represent letters, numbers, and special characters. He estimated the frequency with which various letters were used by counting the amount of type used in a local newspaper office and assigned the simplest code to the most common letters: E, for example, was just one dash. (Interestingly, Vail also used spaces so that O was dot-space-dot.)

The dots and dashes across the top of the page spell out

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When the Morse system was adopted in Europe in 1854, there was no way of representing the accent marks which were used in European languages (for example, é or "e acute") and so a different code was produced: O now became dash-dash-dash-dot. In 1865 a standard **International Morse Code** was produced in which O became the familiar dash-dash-dash.

America, of course, continued to use its own code and this was what Samuel McGowan brought with him to Victoria. It was then adopted by the other interconnected colonies and became known as the **Victorian Morse Code**. Western Australia had its own telegraph network, opening the first line from Perth to Fremantle on 21 June 1869[10] but was cut off from the colonial telegraph network until December 1877 when the lines from east and west met at Eucla. Each colony had its own way of handling messages and, while South Australia still used the Victorian (American) Morse alphabet, Western Australia had adopted the International alphabet. Operators from each colony sat either side of a partition: a message would be received, written down, passed to the other operator, and sent on! Bear in mind that this was a time when colonies had their own jurisdictions and travellers crossing borders had to go through customs procedures.

Another layer of coding was introduced which used single words to represent common phrases, thus reducing the length – and therefore cost – of telegrams. Some words were recognisable and others were nonsense words: for example, in the *ABC Telegraphic Code*, ENBET meant "Captain is insane".[11] Commercial enterprises with far-flung offices also had their own private encryption codes to ensure their messages remained confidential.

Morse Code remained in use for international maritime communication until the end of the 20th century.

With thanks to Laurie Wallace and Andrew Crouch

References

1. "Cooke and Wheatstone Telegraph", *Wikipedia*, <en.wikipedia.org/wiki/Cooke_and_Wheatstone_telegraph>
2. George Prescott, 1866, *History, Theory, and Practice of the Electric Telegraph* (4th ed), Ticknor & Fields, Boston, p79
3. *Argus*, 6 March 1854, p4b
4. *Adelaide Times*, 13 February 1856, p1b
5. *SA Register*, 22 July 1858, p2b
6. The final link connected Adelaide and Sydney through Wentworth; this was open on 30 April 1867 [*SA Register*, 1 May 1867, p3a]
7. *Adelaide Observer,* 13 July 1872, p7g
8. Taliaferro Shaffner, 1867, *The Telegraph Manual*, Van Nostrand, New York, pp403,409
9. "Samuel Morse and Alfred Vail" in "Morse Code", *Wikipedia*, <en.wikipedia.org/wiki/Morse_code>
10. *Inquirer and Commercial News* (Perth), 23 June 1869, p2f
11. *Brisbane Courier*, 20 June 1874, p5c

A sounding relay mounted in a simple wooden box to direct the sound to the operator's ear; photographed at the Alice Springs Telegraph Station, 2009 [Photo: Richard Venus, 5628]