From the Pony Express To Today's Beam Radio

By GEORGE C. HILLIS

To many people, a telegram calls to mind a mental picture of a Western Union messenger boy pedaling his bicycle down the street, or of a Morse operator copying a message by listening to the dots and dashes of a sounder. New and improved methods of operation have made great strides to change this mental picture of telegraphy.

The telegraph was invented in 1832 and mechanically perfected in 1837 by Samuel F. B. Morse. The first practical telegraph instrument, as he termed it, was exhibited in his rooms at New York University. His receiver consisted of a magnetically operated pendulum mounted on a picture frame, marking on a moving paper tape. It was not until 1844 that the first public telegraph message, "What Hath God Wrought?" was sent by Morse over the first line from Washington, D. C. to Baltimore.

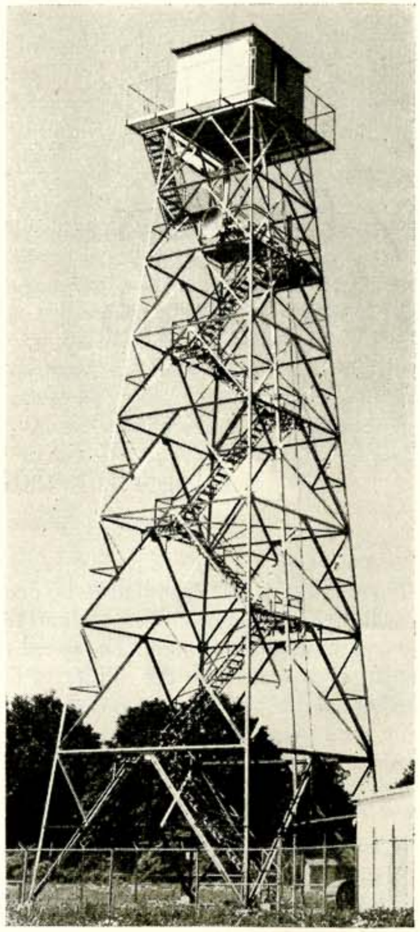
GEORGE C. HILLIS is general inspector for the Western Union Telegraph Co. and makes his home in Chicago. He received his B. S. degree from MSOE in 1929 and is also a holder of the Octave Chanute Medal which was awarded him for the general excellence of this article by the Western Society of Engineers before whom it was originally presented as a paper, and subsequently published in the society's "Journal." It is reprinted, in condensed form, by permission of the society, and has also been published by the Smithsonian Institution.

The marked paper tape had to be deciphered by the receiving operator and the message written on a blank. The speed of operation depended on the ability of the sending operator and the receiving equipment, and was probably less than ten words a minute.

New Apparatus

It took but a short time before the receiving operator found he could read the dots and dashes without having to look at the tape; translating the sound was much easier. Improvement in apparatus allowed the operator to send about 11 dots per second with a semi-automatic sending machine, termed a "bug." Exceptionally good sending and receiving operators could handle an average of 100 short messages an hour.

Duplex telegraphy was invented by the president of the Franklin Telegraph Company in 1872. This allowed simultaneous sending and receiving at each end of the circuit, doubling the circuit capacity. Western Union purchased this patent, then made arrangements with Thomas A. Edison to see if any latent possibilities could be developed.



A view of one of the beam radio relay towers.

After considerable experimenting, Mr. Edison invented the Quadroplex. This method allowed two simultaneous sendings in each direction. The single circuit capacity had now been increased four-fold.

The Wheatstone siphon recorder, an English invention, was brought to this country in 1833 and was used extensively on the earlier cable circuits. It was soon replaced on land lines by a faster type Wheatstone recorder.

Turn of Century

During the period of 1901 to 1910, many printing telegraph systems were developed. The better known were the House system which printed on a strip of paper and the Buckingham system which printed directly on a message blank.

The Barclay system was developed from Buckingham patents about 1904-1905 and was the first printer to stand up under heavy traffic. It was soon replaced by the Morkrum-Kleinschmidt printer, an invention of Howard Krum of Chicago.

About 1912 the Western Union-developed page printer had been installed on the heavier circuits between New York and San Francisco. The first printer had a stationary carriage and movable type wheel. Later on, a type bar printer was developed which used the Baudot code system and is now being used in conjunction with the multiplex. The present 21-A tape printer will handle 72 words per minute.

It was soon found that the line-wire circuit was capable of carrying signals much faster than a single operator could send them or faster than a single receiving printer could print them, clear the selecting mechanism and be ready for a second incoming signal.

Multiplex System

In order to make full use of the circuit, it was necessary to develop a method which could handle signal impulses to the full capacity of the circuit. This system is known as the Multiplex and is used throughout our system to handle the major portion of trunk line traffic.

The teleprinter has almost entirely replaced the Morse method as a means of operating lightly loaded circuits. Most readers are familiar with this machine which sends from a slightly modified typewriter keyboard and receives on either tape or page copy. The sending and receiving units may be operated independently or in series.

The teleprinter uses the five-unit code of the Multiplex with the addition of a phasing and stop pulse. The phasing pulse is necessary to start the receiving distributor with the transmitting cam and the stop pulse stops both the receiving and sending units so they will both start in phase for the next signal.

Supplement the Multiplex and teleprinter, we have the Varioplex, Telefax and Photofax. The Varioplex uses the high capacity of the Multiplex system and by means of a control rack and a number of reperforator racks, as many as 36 teleprinter sub-channels may be operated over a single wire.

Facsimile Development

Telefax and Photofax are Western Union developments of the principles of facsimile. Telefax utilizes the pick-up of a reflected light beam through a photoelectric cell which translates changes of light intensity to corresponding changes of electrical intensity as the scanning beam passes over the copy being transmitted. At the receiving end, the intelligence may be reconverted to changes of light intensity and recorded on a photographic film as a negative. After developing, a print from the film negative will give a positive of the original material from which transmission was made.

The transmission of intelligence from the various types of terminal equipment over open wire land lines has proved to be one of our greatest difficulties in the maintenance of uninterrupted service. The physical hazards of sleet, ice, fires, floods, railroads and vehicular wrecks and tornadoes have caused our Dispatching Bureau many hours of "blood, sweat and tears."

Interference caused by inductive coupling to power lines, lighting and the interference induced by adjacent telegraph circuits have limited the distance over which transmission may be satisfactory without repeaters. When the signals become too badly mutilated, they may be rebuilt by regenerative repeaters, but this equipment is expensive and requires expert maintenance and adjustment.

The radio relay tower at Washington, D. C. Note the fibre-glass windows which are used to protect the reflectors.

A Grounded System

In a grounded telegraph system such as we use extensively, a battery is applied to one end of the wire and the opposite end is grounded, thus completing the circuit through the ground back to the battery. Any disturbance to the earth potential will seriously affect operation over this type of circuit. On the morning of March 23, 1940, approximately 800 volts of difference in earth potential were observed between New York city and Binghampton, N. Y. This meant that with one of the wires grounded at Binghampton, the New York testboard attendant would see on his voltmeter connected to the New York end of the wire, not the Binghampton ground, but anywhere from zero to 800 volts of battery and varying from positive to negative.

At times the maximum potential would hold steady for 30 seconds or more, decrease in intensity, then suddenly reverse potential and increase in intensity until approximately 800 volts of the opposite potential was reached. Under these conditions, telegraph signals of 160 or 240 volt potential were entirely obliterated.

Weather Trouble

Trouble is also experienced during very wet weather when a thin film of water on the glass insulators acts as a high resistance conductor and allows a small portion of the transmitter battery to leak off to the ground at each telegraph pole and return to the transmitting station.

In order to provide a more stable means of transmitting intelligence between terminals which would not be affected by the inherent hazards of grounded operation and provide a number of circuits over a pair of wires, Western Union began experimenting with carrier operation in 1927.

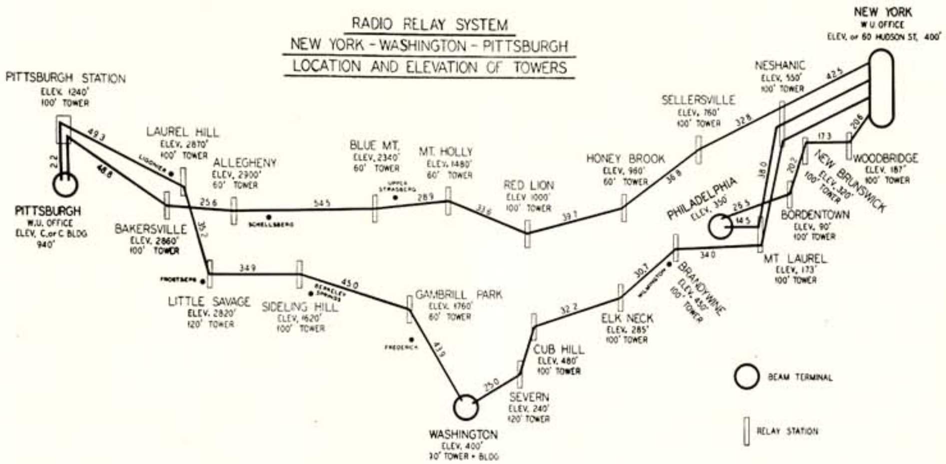
The first four-wire amplitude modulated carrier system was placed in service between New York city and Buffalo. While this system was a great improvement over physical grounded operation, it needed many improvements.

The B-3 system was placed in operation a short time later between New York and Chicago. This was a 4-wire, amplitude modulated system originally designed for 20 operating channels.

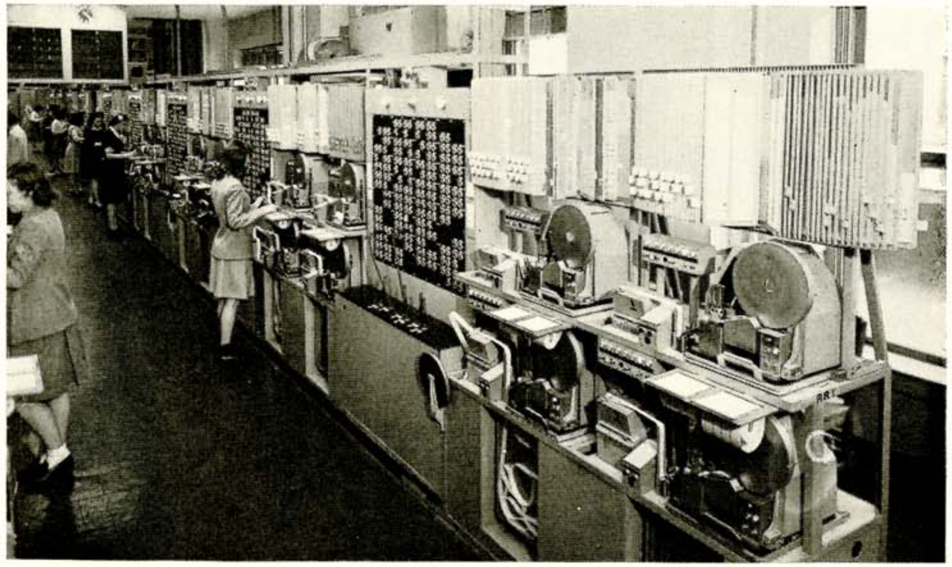
Late Research

Continual research by Carrier System Development Group produced the first frequency modulated terminal in 1937. A series of improvements led to the installation of the first type "E" carrier system between Dallas and Los Angeles in the fall of 1942. This was a two-wire system, using frequency modulated terminals and provided one-voice channel in each direction of transmission.

The Western Union electronic laboratory at Water Mill, L. I., N. Y., has continuously investigated the possibility of radio as a medium of transmission. Up



A diagram of radio relay system between New York, Washington, D. C., and Pittsburgh, Pa.



These girls are at work in a section of the reperforator switching aisle in Western Union's St. Louis headquarters.

to 1940, the use of radio was not advisable for the frequencies used at the time did not provide the continuous 24-hour service the year round that is required for dependable telegraph circuit stability.

The concentrated development in the ultra-short wave spectrum for radar techniques during the war disclosed that when the super-high frequencies were propagated under line of sight conditions, that they appeared to be quite stable. They were not affected by magnetic storms or lightning discharges so it was apparent that this method of transmission might be the answer to our transmission problems.

The Answer

Before the war, equipment was not available to construct oscillators which would generate frequencies much above 400 megacycles. Oscillator tank circuits were reduced in size until the capacity between elements in the vacuum tube was used as tank capacity and a single turn of wire for the tank inductance. The answer to generating still higher frequencies was found in a new type of tube which utilizes the speed of electron travel. Two types of tubes of this classification were used during the war for radar work—the Magnetron and the Klystron.

Western Union has also initiated a comprehensive experimental program for the use of microwaves for commercial telegraphy. A patent license agreement was entered into with the Radio Corporation of America in 1944 for use of the necessary radio circuit patents. Similar arrangements have also been made to use the Armstrong method of frequency modulation.

The Western Union carrier which feeds into the radio transmitter will consist of 32 voice channels, each of which may carry either 16 narrow band telegraph channels, a telephone or a facsimile circuit. The existing narrow band telegraph channels are in two groups of eight, each of which has a frequency spread of 525 cycles for channel one to 1574 cycles for channel eight. By means of a frequency translator, identical terminal equipment is used for the second group, which after translation in fre-

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quency, appears as a band from 2025 cycles to 3075 cycles. Thus the two groups fill a voice channel which has a band width of approximately 300 to 3300 cycles.

Modernization

During the first stage of the modernization program, a number of two-channel Multiplex circuits will be established between the larger offices. These will operate at 66 words per minute or a line frequency of 33 cycles per second. Ultimately, plans are to discontinue the use of the Multiplex, with its complicated equipment and use nothing but teleprinter circuits as the simplicity and flexibility of this type of equipment will more than offset the high load capacity of the Multiplex.

Present plans call for unattended radio relay stations, spaced from 20 to 50 miles apart, depending upon the topography of the land. The location will also hinge upon availability of satisfactory commercial power, as well as good roads.

Strategically located maintenance men will service the equipment at three or four relay towers. They will be furnished with an automobile containing an assortment of testing equipment and spare parts, although it is planned to do most of the repair work at the maintenance headquarters.

Terminal Towers

Terminal towers will contain radio equipment which will translate the ultra high radio frequencies to the 300-150,000 cycle telegraph carrier. These frequencies are sent to the main office of the telegraph company over a coaxial cable and by means of frequency translators and filters, and are separated into the 32-voice bands. The voice bands are either patched to various groups of carrier channel terminal equipment or to voice bands of other carrier systems.

Some of the terminal towers will not only contain the radio equipment but the telegraph carrier voice band translating equipment as well.

The radio relay network is being laid out on a triangular basis as far as possible so that with the failure of any one leg, communication may be quickly reestablished by using standby facilities on the other two legs.

The tremendous capacity of the microwave system will be used to provide the large number of telegraph channels that will be required for our projected reperforator switching systems. The entire United States will be subdivided into 23 reperforator switching centers with each center relaying, by mechanical means, all messages in the area assigned to it. Thus, St. Louis will relay all traffic for the state of Illinois outside of Chicago; Minneapolis will handle everything for North and South Dakotas, Wisconsin, Iowa and Minnesota. Each reperforator office will have direct circuits to every other reperforator point.

Anticipated Results

When all installations have been completed, it will mean that a message from Wausau, Wis., destined from Joliet, Ill., will be sent from Wausau to Minneapolis by teleprinter signals over a Wausau-Minneapolis feeder carrier system. At Minneapolis, this intelligence will be re-

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ceived on a printer perforator and appear as a strip of perforated tape with the message being printed along the edge.

The receiving switching operator, noting the Illinois destination, presses a button which will start the tape through a transmitter and switch the signal to terminal equipment sending to St. Louis. The message appears at St. Louis on printer-perforator tape and the receiving switching operator, noting the Joliet destination printed along the edge, will press a button which will connect the transmitter associated with the Joliet circuit so that within a matter of minutes, the message will be received on the teleprinter at Joliet. Only two switchings will be necessary to send a message from St. Petersburg, Fla., to Sacramento, Calif., one at the Florida reperforation center, and the other at its California counterpart.

Now, for the first time, we can send telegrams from any independent Western Union office in the United States to any other independent office in a matter of minutes. By means of the radio relay, which will supply the multitude of circuits required and working in conjunction with the reperforator switching systems, we will have speed and dependability that was only dreamed of a few short years ago.

There will be no more worrying about ice on the wires, boys shooting insulators, heavy wet snow and ice breaking off telegraph poles, magnetic storms, and all of the other hazards of wire communications. Great strides have been made since the days of the Pony Express. We are truly upon the threshold of a new era in written communications.