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A Technical History
of
Marconi's South Wellfleet Wireless Station, 1901-1922

by

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For the benefit of communications and other interested electronics people, we present this information on spark-gap transmitters as a supplement to the largely personal Marconi story for sale at the Visitor Center. We recommend the purchase of the sales booklet for its general history and its valuable photographs.

The writer is not an electronics expert. There will be no doubt some errors. In some cases, what will appear to be errors are only differences of opinion. We are also much indebted to Mr. Fred Parsons of New York, W2EXM for Figures 2, 3, and 4, and for the technical matter following Figure 4.

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In 1902, following the disaster which destroyed Marconi's circular mast arrangement on Cape Cod, four towers were erected to support the antenna; transmitting equipment was fully installed, and the station began transmitting in January, 1903.

Physical Layout of the Marconi Station at South Wellfleet

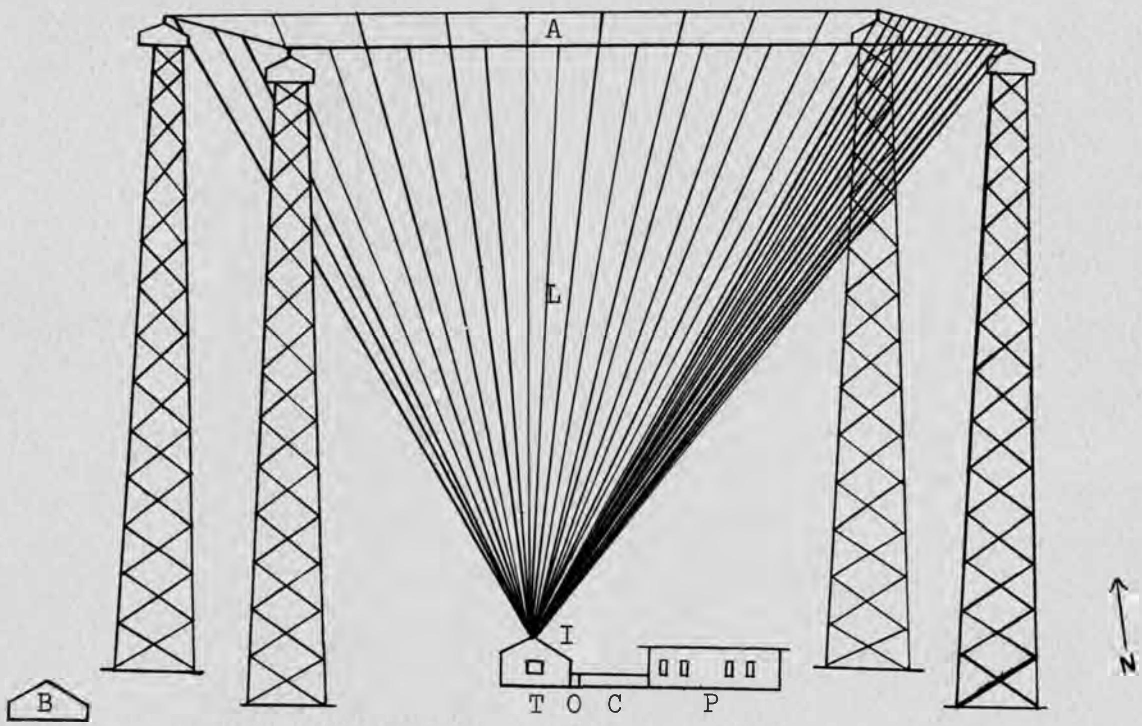

Fig. 1

A--Antenna
L--Lead-in wires
I--Insulator
T--Transmitter House

O--Operator Room
C--Corridor
P--Powerhouse
B--Bungalow (Hq.)

THE TOWERS

The four towers arrangement of 1902 matched installations at Glace Bay (Nova Scotia) and Poldhu, England. These four towers were each 210 feet high, 24 feet square at the base, and 8 feet square at the top. Base legs (corners) were set on and in concrete bases which were 30 feet square and 4 feet thick.

The technique of putting up the towers was as follows: The tower corners were built of four 3x12 inch timbers, bolted together. A short section of each corner was cemented into the base which was 3-4 feet thick--that is, the cement was poured around the corners. After this had thoroughly set, the next section above was bolted on, etc. The 3x12's used for the foot-square corners were "staggered" so that no weakness would appear in the structure. The cross pieces were also 3x12's, showing Marconi's gift for simplicity. The towers were painted a barn red color.

Referring to Fig. 1, the towers were set in a square, 200 feet apart. When set up in 1902, the easternmost ones were at least 165 feet from the cliff edge overlooking the Atlantic. By 1906, it was apparent that the towers had been placed too close to the bank, but by the time this became a factor, the station was already obsolete.

TOWER RIGGING

Rigging, not shown in Fig. 1, was as follows: Each tower was secured in four directions by three levels of one-inch steel cable (12 guys to a tower). Their anchors were called "dead men", and consisted of crossed timbers ten feet long and one foot square. Heavy chains were cemented to these crossed timbers which were buried eight feet in the sand. The guys were then attached to these chains and adjusted when necessary by heavy turnbuckles. Some of these "dead men" are on exhibit at Marconi Site.

INSULATORS

So-called "dead eyes" were used to break the guy wires into insulated sections. These "dead eyes" were made either of Lignum vitae, a very hard wood, or oak, and were customarily used in sailing ship rigging. Marconi's engineers probably got the idea of using sailing ship "dead eyes" from the Boston company which had supplied the original 1901 spars and rigging. (See Fig. 2).

The insulators which were used to suspend the antenna from the masts were constructed of rope and rubber hose, the ends of the latter being filled with melted sulphur. If the rope outside the rubber became wet, current would not flow through the dry sulphur-sealed rope inside the hose. (See Fig. 3).

(A few dead-eyes and rubber insulators are on hand in the museum storage vault at Cape Cod Visitor Center, Eastham). Of course, small porcelain and glass insulators were used where great strength was no object.

THE ANTENNA (AERIAL)

The first 4-tower antenna erected at South Wellfleet consisted of forty, heavy-stranded copper wires in a bundle with 200 lead-in wires in the form of an inverted pyramid. (Fig. 1). These converging lead-ins were attached to a "floating" half-ring insulator (not shown in Fig. 1) suspended above the transmitter house. From this half-ring, a single heavy lead ran through a water-proof box on the house top and into the structure. Probably, the floating ring insulator permitted some flexibility, and was less likely to break the lead-in during high winds.

Later on, it was decided to use the South Wellfleet station exclusively for broadcasting press to ships, and the "cone" lead-in arrangement was changed to a twenty wire spread which ran from the tops of one pair of towers to the tops of the others, and zigzagged down in a "Z" shape to the Transmitter House.

A counterpoise was employed because the sand made an unsatisfactory "ground". (See Fig. 4).

THE TRANSMITTER HOUSE

This frame building with concrete floor measured 30x30 feet and was placed in the center of the four tower area. (Fig. 1). In this structure was the following equipment: (See Fig. 4).

The condenser (capacitor) consisted of foil-wrapped, heavy glass plates immersed in oil. Some 20,000 volts (electrical pressure) was available from this source. Above the condensers, to the left or rotor side, was placed an oscillating inductance coil (H in Fig. 4). To the right was the antenna tuning inductance coil (J in Fig. 4).

The heart of the rig was the three foot whirling spark-gap rotor (R in Fig. 4). The spark gap was not muffled, and with 30,000 watts of power, the crashing spark could be heard four miles downwind. To eliminate destructive arcing and to secure a clean break at the spark gap, compressed air jets blew out the arc as the circuit opened (Parsons).

The tuner was not too efficient, and the station's tuning had to be improved later because of its tendency to interfere with other transmitters.

Marconi station operated a 2-1/2 KW (2500 watt) ship-to-shore transmitter (call letters WSW which operated until 1913 on the 600 meter band and was a more reliable apparatus at night than the big 30 KW transmitter was during the daytime. Mr. Wilson states that "ships used to ask for repeats of messages on the 600 meter transmitter when they had failed to hear them on the larger set when the latter was used for daytime operation."

That the sun adversely affected daytime transmission was an early discovery of Marconi's--he was aware of the advantages of short waves for communications, but the high frequency short waves produced by spark-gap transmitters were not "sharp" enough and did not radiate as effectively as do continuous HF waves produced by modern short wave transmitters.

THE OPERATOR'S ROOM

Just to the East and attached to the Transmitter House was a small Operator's or Transmitting Room. (See Fig. 1). An old photograph of 1902-03 indicates that this small room (no more than nine feet square) originally sat next to the powerhouse (see Fig. 1) but was probably moved to its permanent location because of the desirability of the operator's viewing the spark-gap. He was able to do this by looking through a double glass port-hole in the sound-proofed door. Naturally, the operator rarely, if ever, entered the transmitter room while the rotor was spinning; such a move would have been dangerous and the noise, even in the operator's room, must have been tremendous.

The operator sat on an insulated wooden stool at a bench on which rested the very elementary equipment of its day. In the beginning, this operator had to work the telegraph key by hand, using a so-called "pump handle" which required much effort to work. Voltages were dangerous also, and it was not long before the "pump handle" was replaced by Morse automatic equipment (a Wheatstone-Morse landline transmitter attachment). News was received by direct telegraph line from the New York *Times* via South Wellfleet thence by sand-dune line to the station headquarters (the Bungalow).

Of course this was in Morse Code, so the news was transferred to tape using the International Code, the tapes hand-carried down to the Operator's Room and sent out by the automatic apparatus, 10: P.M. to 1: A.M. Private messages could be sent for 50¢ a word.

THE CORRIDOR

A covered passageway connected the Transmitter House and Operator's Room with the Powerhouse to the East. A sealed, high voltage line ran along one side of this corridor. (See Fig. 1).

THE POWERHOUSE

This, a red brick building, measured about 30x60 feet. (Fig. 1). The engineers installed two De-la-Vergne kerosene oil reciprocating engines. One was a 45-horsepower engine belted to a 45-kilowatt alternating current generator which supplied 2200 volts to a Tesla transformer, the secondary of which stepped up the voltage to 20,000 volts which were "stored" by the big capacitor in the Transmitter House. This AC generator also drove the large rotary gap motor in the Transmitter House.

The smaller oil engine turned a DC generator which kept a large 110-volt stprage battery charged. Current from this battery "excited" the field coils of the big AC generator, supplied station lighting, and supplied the energy for the ship-to-shore wireless previously mentioned.

Mr. James Wilson, ex-Marconi operator at South Wellfleet, states that the small engine was also used to help start the big engine on cold evenings, and each night in winter, before operations, the cylinders on the main engine had to be heated before it could be started.

THE DORMITORY (OR BUNGALOW)

The headquarters for the staff was a fairly large frame building measuring 20x60 feet with plank flooring set above the sand. No trace remains of this structure which stood perhaps 200 feet west and south of the station, outside the four-tower area. All hands--two engineers, a manager, and three operators--lived here. Two riggers and a cook came out from town to work.

As we have stated, the news from New York was received here by Morse telegraph and taped for transmission.

TECHNICAL OPERATION (Transmitter)

The schematic diagram of the Powerhouse, the Transmitter House, and attached Operator's Room, are shown in Fig. 4. The original of this sketch was drawn by Mr. Fred Parsons of New York, and is useful in explaining the technical workings of the South Wellfleet installation.

This is a so-called "schematic" diagram except that, in Parson's words, "is not to be considered an actual circuit arrangement but it does serve to show the electrical association of the apparatus, and in the main, is a correct plan of the South Wellfleet (station)."

The following is directly quoted from Fred Parsons on the technical operation of the station. (Use with Fig. 4).

"The big oil engine in rotating the alternating current generator (generally called an alternator) effected a conversion of mechanical energy into alternating current power. This 2200 volt current was supplied to the "primary" winding of the transformer and because of the faculty of this device to "step up" the input voltage, a much higher voltage (20,000 volts) appeared across the terminals of the "secondary" or output winding. This output was conducted over well insulated

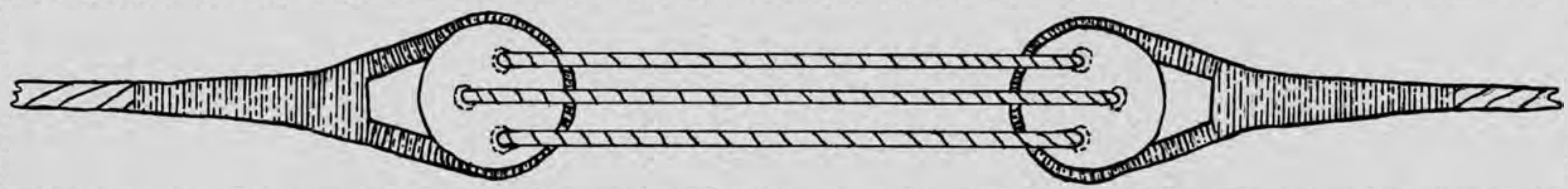

Fig. 2

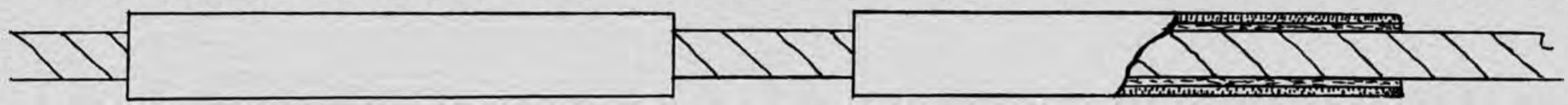

Fig. 3

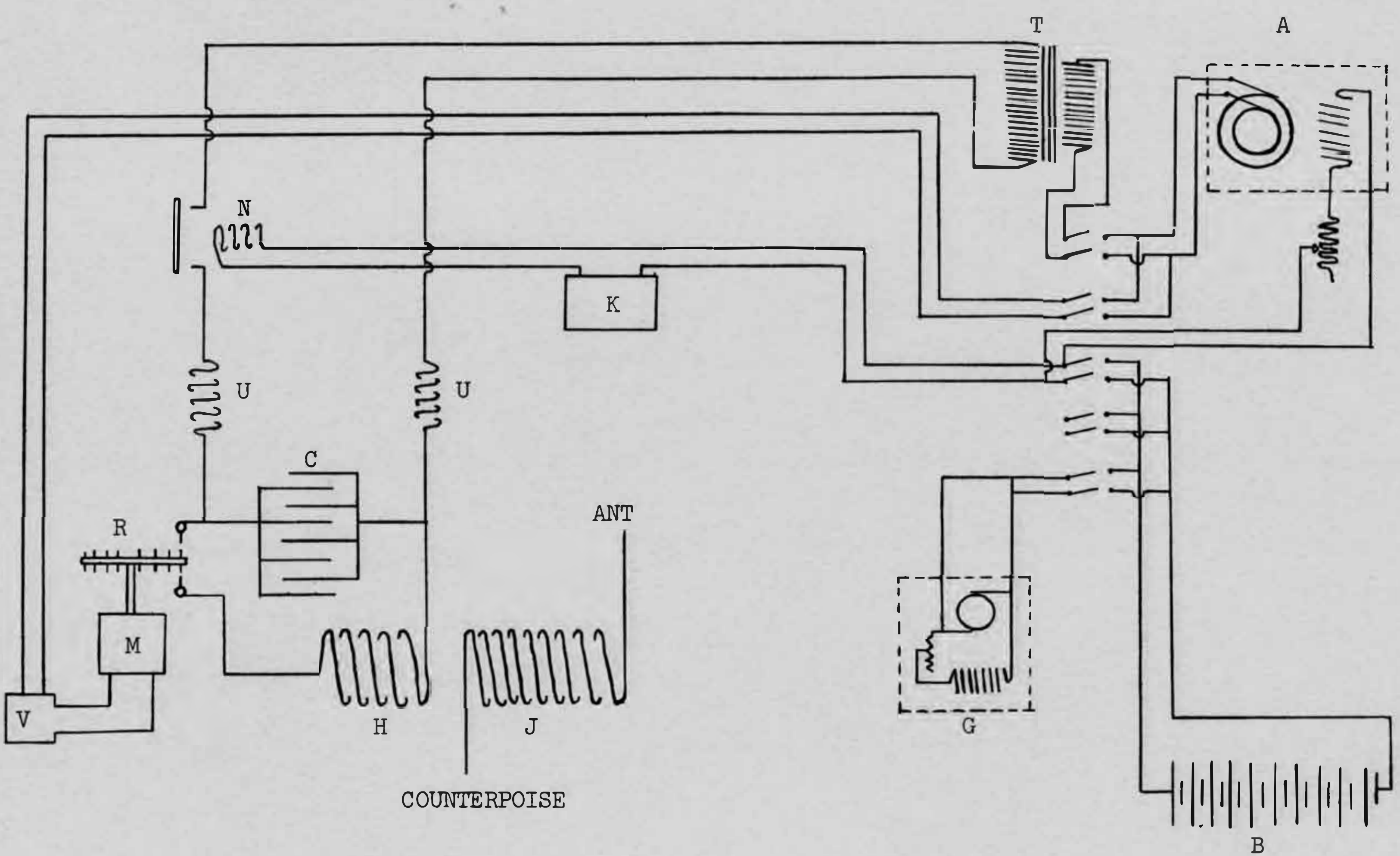

Fig. 4

A--Alternator, 60 cycle
B--110 volt storage battery
C--High tension transmitter condenser
G--110 volt battery charging generator
H--Oscillating circuit inductance
J--Antenna tuning inductance
K--Tape machine for automatic keying

M-- Rotary spark gap motor
N-- Main high voltage keying relay
R-- Rotary spark gap
T-- Main high voltage transformer
U-- Radio frequency chokes
V-- Rotary gap motor start box

cables to the transmitting room, and when the keying relay was operated by current supplied under control of the tape transmitter, charged the high tension condenser. The condenser in effect is an electrical reservoir capable of holding the charge impressed upon it. During this time the rotary gap alternating current motor received power from the main alternator and spun the rotary gap which had insulated metal studs mounted near the periphery of the disc and parallel to the gap shaft. These studs in extremely rapid succession passed between two stationary studs, one of which was connected to the condenser and the other to the large "Primary" coil of the radio frequency transformer and another wire connected the other condenser terminal to the other primary inductance (as the coil was called); thus was formed a circuit of the condenser, spark gap and coil in series.

If a gap in a circuit was sufficiently small and the voltage high enough, a spark would jump across, and this is what happened at the rotary gap. When a rotating stud of the gap was almost in line with the two stationary studs the air resistance was at about minimum and then the condenser discharged its power across the gap in the form of a spectacular roaring spark. These pyrotechnics were in a sense by-products, for the important thing that occurred was the development of high frequency electric oscillations in the series circuit, before described.

The frequency with which these oscillations surged back and forth depended upon the electrical values of the condenser and inductance; the bigger the condenser (or capacitance) and the bigger the inductance (in size and number of turns) the lower the frequency or longer the wave length. To secure high power, the condenser had to be of high capacity and so the wave length of the station was long--1800 meters.

Immediately after the spark occurred, the moving stud of the rotary gap left the stationary studs and effected what is called "quenching", which contributed to a sharply tuned wave, and as the moving studs passed the stationary ones at the rate of 240 per second, the audible tone of the signal assumed that value and produced the pleasing musical tone for which the station was famous. (This electric motor which drove the rotor was not synchronized with the big alternator (A, Fig. 4), but it seemed to achieve a natural synchronization).

The secondary coil (or antenna coil) of the radio frequency transformer was adjusted in electrical size so that the antenna system was in electrical "resonance" or tune with the rate of oscillations in the spark gap circuit. This transformer had three functions:

1. To couple inductively the antenna to the transmitter giving a sharply tuned signal.
2. To increase the voltage in the antenna circuit.
3. To provide a flexible means of adjusting the tuning of the two circuits.

Each time the condenser discharged across the gap at the rate of 240 cycles per second, the radio freqnency circuit oscillated at the rate of 200,000 cycles per second. The former gave the tone audible in the receiver and the latter in effect was the electrical carrier of the energy radiated into space. In other words, a series of pulses at audible frequency, each composed of a train of radio frequencies, was emitted. The radio freqnencies were generated in the first place simply because only these would radiate from the antenna."

SIMPLIFIED TECHNICAL OPERATION, RECEIVER

The primary function of the Marconi station at South Wellfleet, Massachusetts, was as we have shown, transmission.

Some knowledge of a spark-gap Receiver will be of use to a young student.

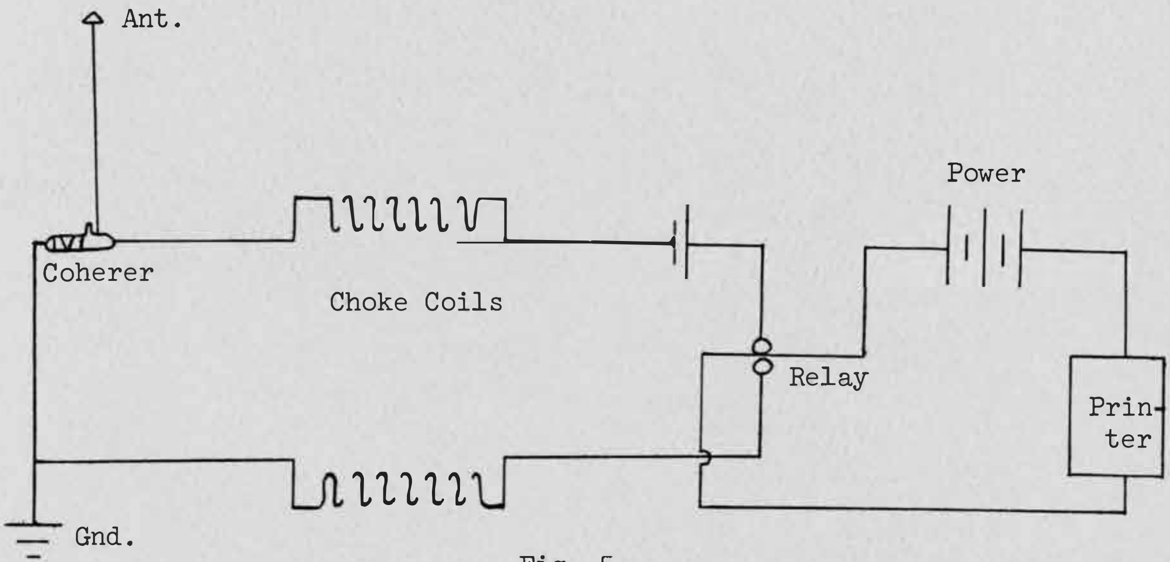

Fig. 5

Receiving was as follows: The electromagnetic waves broadcast from the spark-gap transmitter's antenna excited high frequency oscillations in the receiving antenna and tuner which was adjusted to pick up the specific wave length broadcast. These signals caused the coherer (detector) to operate by closing the switch or relay and permitted the local circuit to flow and thus activate the printer. The choke coils prevented any current from the local circuit from leaking back into the antenna system and fogging incoming signals. Actually, as current from the local battery activated (closed) the relay, the relay caused another and stronger current to work the recording instrument and also caused a tapper to shake the coherer which was again sensitized and ready for the next impulse. These electromagnetic waves travel at the speed of light--186,000 miles per second.

The practical result was that the circuit of the recording instrument was closed (current was flowing) for a time exactly equal to that time the operator had pressed the key at the transmitting station. If he tapped a dot, the impulse carried by the wave was short, and the recorder impressed it as a dot--if he held the lever down for a dash, the impulse carried by the wave was longer and the recorder showed a mark exactly equal in length to the impulse sent at the key. This is graphic reproduction.

If a phone was used as a receiver, the dot "tone" was heard, or a dash (longer tone) was heard, depending on the time length of the key being held down. This was acoustic receiving.

The Coherer

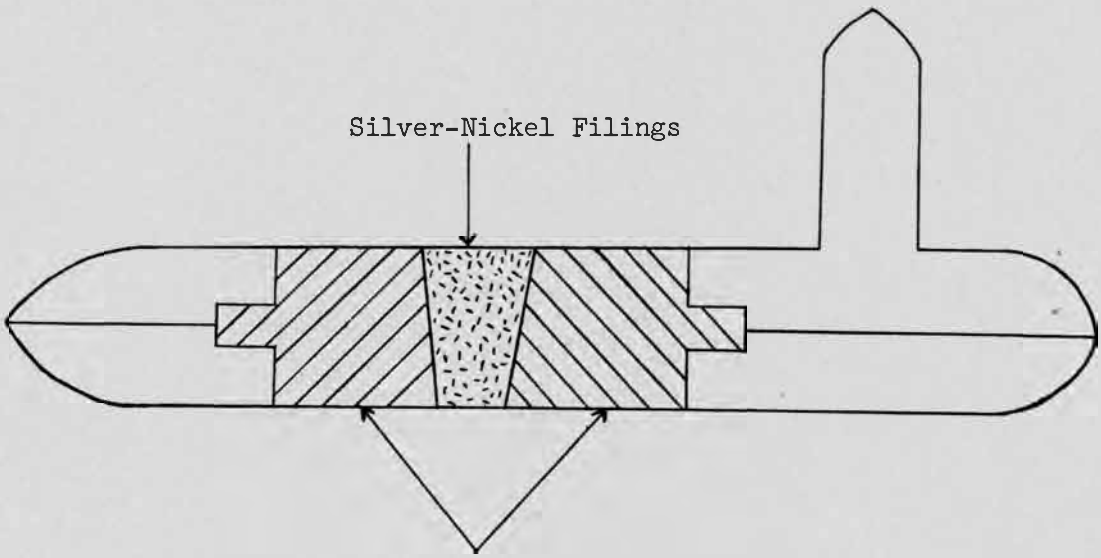

Fig. 6

The Coherer (detector): This little glass instrument detected signals because a current flowed through the nickel and silver filings only when their resistance was lowered by a radio frequency wave--the Coherer had infinite resistance to ordinary current. An electric bell mechanism (invented by Marconi) vibrated the Coherer to restore its sensitivity after each pulse.

CONCLUSION

Marconi Station at South Wellfleet, Massachusetts, began its career with the call letters CC, later changed to MCC, and finally to WCC when radio and spark-gap transmitters on the Atlantic coast were assigned the letter "W".

The Radio Corporation of America (RCA) bought out the American Marconi Company about 1919, and the RCA communications, Marine Division station at Chatham, Massachusetts, still uses the call letters WCC.