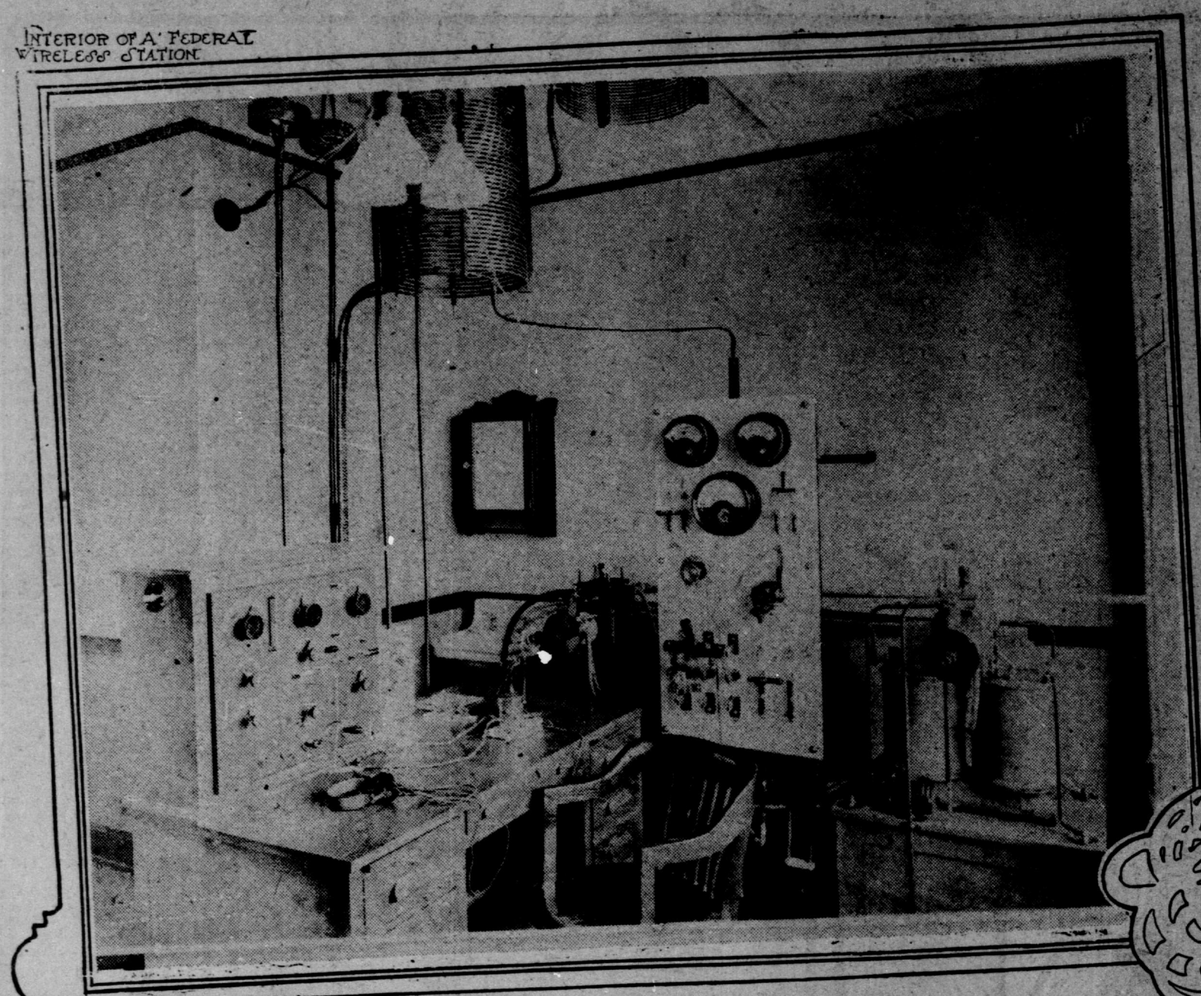
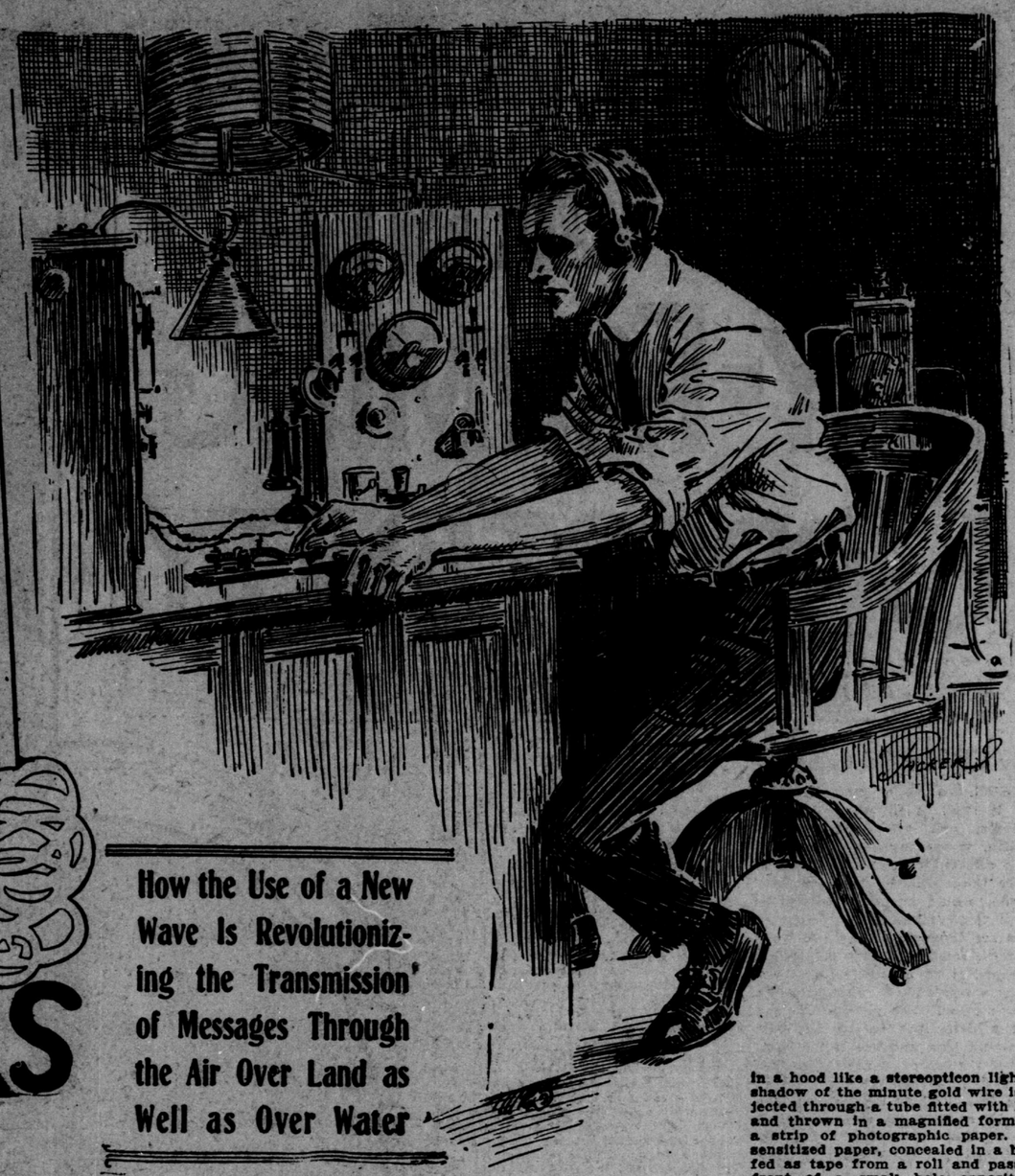


INTERIOR OF A FEDERAL WIRELESS STATION



WIRELESS WONDERS WORKED IN SAN FRANCISCO

How the Use of a New Wave Is Revolutionizing the Transmission of Messages Through the Air Over Land as Well as Over Water

THE physical limitations that have heretofore stood in the way of the full and complete development of wireless telegraphy have at last been swept aside. No points now exist on land or sea that can not soon be reached by radiograms as reliably as by the old direct wire method. A regular commercial business by wireless is certain to be a universal fact.

Previously the wireless had been successful only on the water. Its handicaps were many. Yet, even then the taking of "freak" messages from seemingly impossible distances was not uncommon. There were times when the unusual kindness of the ether allowed San Francisco to pick up a few words of some message flashed at Kansas City or, as in one case claimed as authentic, from a station in Japan. Such "freaks" were, of course, not only rare but fragmentary. But at last the wireless has subjugated the forces of freakdom. And it is from our own San Francisco that these latest developments come.

At a point in South San Francisco, close to the water, the Federal Telegraph company has just finished the largest and most complete wireless station in the world. It represents the latest word in the history of radio communication. It means that overland sending, once considered impracticable, is now easy and accurate, and that the greatest ocean span in the world, the 2,350 statute miles from here to Honolulu, has been successfully bridged.

When a few more stations such as this have been placed in line, a message from New York to any part of Asia or Australia will be a matter of only a few relays.

But large jumps over space form but one of the seemingly miraculous accomplishments of the new system of wireless.

Messages sent and received at the rate of 300 words a minute are now a mere commonplace at the South San Francisco station.

The duplication of sending and receiving, by which the same antenna—the wires suspended between the mast tops—handle four different sets of messages at the same time by sending two and receiving two independently, is likewise a commonplace.

Another feat no less remarkable is the elimination of annoyances caused by amateurs and rival companies. This feat is done by regulating the electromagnetic wave length so that it may be received only by the station for which the message is intended.

Day sending, heretofore accomplished only at comparatively short distances as against the work done at night, has also been mastered.

Yet all that wireless telegraphy may do is likewise possible for the telephone. Experiments have established that fact. So far, however, the efforts of the experimenters have been concentrated on telegraphy. When its problems are completely mastered, similar attention will be given to the telephone.

One result of wireless development will be quickly appreciated by San Francisco. Winter storms have only too often isolated the entire Pacific coast from the world. In view of messages being sent from this city straight through Mount Whitney, the highest peak in the United States, to El Paso, as is now done daily, snows and winds cease to be factors. Were a disaster to wipe out a single station, another at an attainable distance may be used. But even then the setting up of wrecked masts is an easy job as against restringing miles of wire over storm torn mountains or flooded lands.

Another important fact to impress the commercial world is the ease with which the wireless jumps over space. There is no appreciable difference at the local station between sending to Stockton or to Honolulu. But to a wire system distance is an unavoidable factor in the establishment of rates. Every mile overland means a heavy investment in poles, insulators and wires, as well as a heavy toll in keeping the lines repaired. Cables are still more expensive. The trans-Pacific cable cost $2,750 a mile, while the expense of maintaining a repair ship to mend breaks has averaged $40 a year for each of these expensive miles. A sharp coral reef means a long trip for the repair vessel and a lot of troublesome grappling on the ocean bed, which may be miles deep. In comparison the expense of wooden masts for a wireless station is a small item.

While California enterprise has pushed wireless development to its present state, the discoverer of the new method is a Dane. His name is Valdemar Poulsen, whose patents are now used by the military and naval departments of Denmark and Germany. The possibilities of the Poulsen system were early seen by C. F. Elwell, a Stanford graduate who had specialized on wireless problems. It was he who interested Beach Thompson and other local capitalists in Poulsen, with the result that the Federal Telegraph company was organized. Prof. C. D. Marx, head of Stanford's engineering department, is a director of the company. Many purely scientific questions, it may be said, are worked out in the company's experimental station in Palo Alto. But besides the improvements originating there, Dr. de Forrest has done some important work in overcoming mechanical handicaps at the wireless stations at South San Francisco and the ocean beach.

After building a large station near the beach boulevard, which is still in use and will be retained, the company tried Los Angeles. Messages were carried with such ease that a commercial business was established. But this did not entirely prove the efficacy of the Poulsen system overland, since San Francisco is by the sea and Los Angeles also near it. Stockton then did such efficient work that the system was completed. Messages are now carried to Chicago by way of El Paso. But the smallness of these stations has hitherto been a handicap. Masts of the size just built in new South San Francisco station will soon be placed in a direct line from here to New York. To the west another station on Wake island, half way between Hawaii and the Philippines, which is in contemplation, is all that is needed to complete the conquest of the Pacific.

It is hard for the "lay" mind to comprehend how these intangible electric forces are controlled. Yet, they are not only controlled, but even measured. It is difficult to grasp the fact that earthly solidity is a relative matter, and that Mount Whitney is no more of an obstacle to the wireless than a straight stretch of air. The atmospheric gases, through which sounds are communicated to the ear, have nothing whatever to do with the wireless, whose pulsations are carried by the ether itself. Yet there are other disturbances quite as serious. The ether that pervades the universe has at times so much work to do in transmitting light that it has little energy left for aerograms. That is why some wireless systems still work exclusively at night. Poulsen has largely overcome the obstacles that beset wireless in daylight hours.

One who visits the new station must go prepared for strange things.

In the first place there are the two masts, at the present time the tallest in the world. They are of wooden truss construction, six feet square, reaching 440 feet into the air and steadied by steel cables stretched from various points to fastenings buried in the earth. The masts stand two city blocks apart. Between their tips is stretched seven miles of sensitive wire feelers, known as the antenna, which gives off and receives the electro-magnetic waves of the Morse code.

These poles are about the only thing about the place that the uninformed outsider can mentally grasp. Inside the small cabins at their foot, he develops an uncanny feeling. Here are housed the contrivances that send out and receive the impulses. Instruments are shown which count oscillations up to the millionth part of a second and measure their length, which may be around a thousand feet. These things are as easy to the man who knows how as the figuring of cordwood to the rancher.

Before dismissing the subject of poles, it is well to correct a fallacy that bothered the early experimenters. Investigators used to think height was an advantage in overcoming the curvature of the earth. The wireless station on Mount Tamalpais was built on this theory. But the results achieved by the Federal people prove that distance above sea level has nothing to do with the case—which is quite a different thing from saying that height above the surface of the ground is not an advantage, for it is a decided one. So great is the length of these electric waves and so low their "dip," that high poles and great length of antenna are absolutely needed for long distance work. Nearness to water is another advantage. So the Tamalpais station is said to be less effective than would be one of similar size on the seashore.

To understand how the land has been conquered by wireless, as well as the sea, and how 300 words may be sent and caught in one small minute, one must appreciate the difference between the old "spark" system, which is now almost universal among vessels plying both the Atlantic and the Pacific, and the steady and uninterrupted current used by Poulsen.

The main difference between the two systems is made clear by Howard P. Veeder, secretary of the Federal company, with these illustrations:

"In the spark system, dots and dashes are formed by breaking the current. Thus the electro-magnetic waves thrown off are like those caused by a splash in a pool; they are irregular in size and weaken as they travel toward the bank.

"Poulsen, in contrast, sends off waves of regular length and formation, which roll like the billows of the sea, each wave reinforcing the other. Dots and dashes are formed in his system by altering, without breaking, the wave lengths. This steadiness of pulsation is the thing that makes the Poulsen system so reliable at long distances and so little disturbed by the etherial activities of sunlight during the day. The spark system works ordinarily ten or twelve times as far at night as in the day, because of such disturbances, while the Poulsen instruments feel this handicap lightly."

With these general ideas in mind, the casual visitor to the Poulsen station house does not find it quite so difficult as he expected to grasp the meaning of the apparatus around him. At first entrance, he is likely to be a little disappointed, for a wireless station without a blinding and theatrical flash and thunderous crackle doesn't seem natural. The Poulsen operator works unobtrusively with an ordinary telegraph key; and the only sound suggests frying fat, caused by the Poulsen generator.

This generator is about the most important thing in the shop. It is an iron box sitting above a pair of big magnetic coils. Inside the box are a couple of large carbon rods set a small space apart, end to end. The chamber is locked and kept filled with a hydrogen gas. Common illuminating gas generally is used, but when not attainable, ether or alcohol may be fed in from an oil can. Water circulates through an outer covering so as to keep the chamber cooled. This contrivance knocks out from 200,000 to 1,000,000 long, regular waves to the second. Electricity in this form has no effect on the human body; and enough current may be sent through one to light an incandescent lamp or even a carbon arc without the person used in its transmission feeling it. On account of its "high frequency," the use of the telephone under the Poulsen system is as unlimited as telegraphy itself. Only, so far the work of development has been given almost exclusively to the telegraphic end. Speaking by the Poulsen wireless is said to be far clearer than over the ordinary wire system, since on long distance wires, speech is often made unintelligible by a humming and buzzing. This humming noise is eliminated by wireless. Mr. Elwell, as long as two years ago, carried on wireless conversations from Stockton to Sacramento, a distance of 50 miles overland, and his conversation was overheard at Palo Alto, 85 miles away.

The next thing to puzzle the wits of the outsider are the copper coils fastened to the ceiling of the room. These coils give the Poulsen method a privacy unknown to the spark senders. When a spark station is sending, all other stations of the kind in radius receive the messages, which accounts for the frequent jumble between naval, commercial and amateur operators in the bay cities. The special Poulsen feature is the "tuning" that cuts the spark rivals out of its field. To borrow another Veeder illustration, if a pistol (which represents the spark impulse) is fired near an open piano, all of the strings are set in vibration; but if a tuning fork be struck, which gives off sound waves of equal length (comparable to those of the Poulsen generator), then only the strings attuned to that note give out a response. The current in the Poulsen system is always unbroken, but short circuits made through the copper coils by means of the Morse key send out a different set of electric waves. These waves, forming the dots and dashes of the Morse code, are caught only by the station properly attuned. Each station from Seattle to San Diego has its "note," so that it may take messages without interruption from the others. If the message is to be general, all stations may tune to the same note, on instructions from the sender.

The Poulsen receiver looks quite like the ordinary telephone earpiece worn by telephone girls. By means of electromagnets and vibrators the waves to which the instrument is attuned are caught and made to emit a humming sound—a short hum means a dot and a long one a dash. If the impulse is weak it may be increased several fold by means of an instrument recently invented.

No sooner does the visitor get a glimmering comprehension of these facts than he is put up against a machine that should scare a married man out of his wits. It is a machine that talks from 150 to 300 words a minute. On examination the machine appears less formidable.

The sending rate by the spark system is from 15 to 20 words a minute. Poulsen hand sent and the ocean cable run from 25 to 30. The rate of sending and receiving has thus its human limitations. To send or to receive 200 words a minute would be absolutely impossible for human hand or ear.

The rapid fire system of telegraphy is patterned after the music roll of the mechanical piano player. Instead of waiting for the wires to clear, the operator sits in front of a punching machine feeding from a roll of tape. It has two keys—one for the dot and the other for the dash—and a spacer. He should be able to perforate the tape at a speed much in excess of the speed of telegraphing by hand. The tape comes prepared with a central line of small holes, the dash or the dot being punched on its respective side of this line. After the tape has been finished, either as a news report or a series of commercial messages, it is fed into a sending machine. The central series of holes fit into the teeth of a sprocket, by which the tape is led with mechanical accuracy. On passing through the sender the dot and dash holes in the thick paper are met by a series of small pins. These pins are pressed back by the tape, but spring out when released by the holes. The small pins in turn release larger pins, which operate a set of brushes, throwing the current to one of three revolving wheels. These wheels are insulated, except from copper strips set in at regular intervals. The one in which the conducting and nonconducting segments alternate at short intervals represent the dots, while the other two wheels with fewer and longer conducting strips send out the dashes. These throw on and cut off the circuit for which the receiving station is attuned.

What limits the speed of the sender (which may be lowered even to the hand sending rate, but proves illegible after 300 words) is the imperfection of the receiver. Yet the receiver is by far the more wonderful machine to the uninformed visitor.

The Poulsen rapid receiver may be compared to a moving picture taking machine. The main part is, however, like the sensitive magnetic needle used in cabling. This magnet, on receiving impulses from the antenna, moves a gold wire so fine that it would be almost invisible save for a coating of soot. This wire is given a quick jerk for a dot and held for a dash. Here is where the moving picture comes in.

By means of a small, bright lamp set in a hood like a stereopticon light, the shadow of the minute gold wire is projected through a tube fitted with lenses and thrown in a magnified form upon a strip of photographic paper. This sensitized paper, concealed in a box, is fed as tape from a roll and passes in front of a small hole opposite the lenses. As it revolves past the light spot, the shadow of the wire is left upon its surface. Every oscillation of the wire is thus recorded. The paper then winds by a small motor through a developing bath, where the part exposed to the light becomes dark, in the manner of a photographic negative. The movements of the wire thus appear on its length as a zigzagging white line. The message may then be translated from the tape as received, or dried and kept for a later reading.

Before tape is either sent or received, preparations are made between stations by the ordinary key and receiver. But from then on there is no interruption. It is not an undramatic scene to receive in the darkened room, when the wet, slippery tape worms out of its case into the hands of the operator. Clear, legible messages have been received from 200 miles over land at the rate of 300 words the minute, and from over 600 miles distance at the rate of 150. At the new station, the rapid talking was done with Los Angeles on the first Sunday of its opening.

Another piece of Poulsen wizardry is the duplexing of the wires. It is only on this system that two messages can be sent or received at the same time. The duplexer, a rough looking machine for the delicate work in hand, is a pair of wheels driven together by a belt from a motor and touched by copper brushes. The waves passing over the antenna run into hundreds of thousands the second. By means of the wheels the direct current is divided as it comes from each key, or as received from the antenna. The different wave lengths are made to alternate, but so quick are the interruptions that the trick is not felt by the instruments. The triplication of the wires is merely a mechanical problem, which will be overcome in time.

It is an interesting fact that the new South San Francisco station, equipped for a regular business with Honolulu as well as inland points, uses only one-thirtieth of the electric power needed to operate the spark system between the coast of Newfoundland and Ireland, which is about 400 miles the shorter distance.

The new Poulsen station uses 30 kilowatts, while the old one on the beach has been satisfied with 12.

Now that the 440 foot masts have justified themselves, it is the intention of the company to plant a series due east to New York. At present messages are carried into Chicago by means of the smaller and hence less efficient stations of El Paso and Fort Worth.

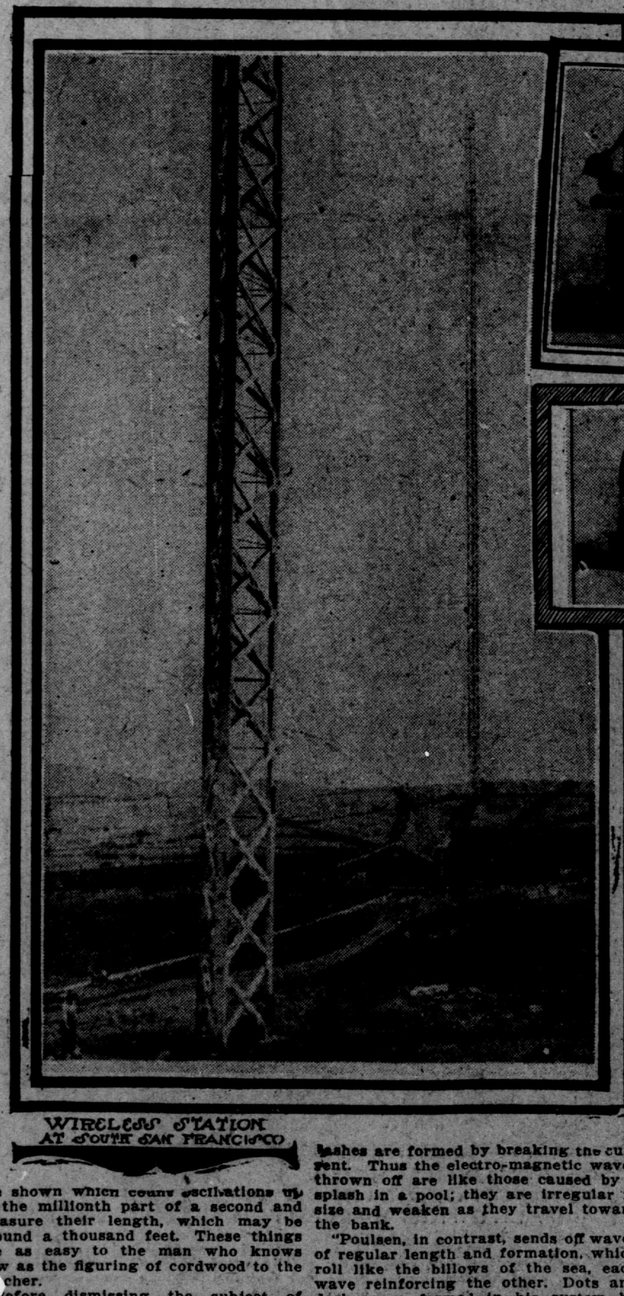
Wireless telegraphy is rich in dramatic incident. But of this the public at large is acquainted with only the tragic end, such as the desperate efforts of the Titanic to get help. There are other curious happenings of a milder kind and not less romantic.

During the first experiments with Honolulu the local station had the use of the small masts of the interisland wireless of Hawaii. The antenna there could receive from San Francisco, but was too short to reply. One night the island operator distinctly caught spark messages sent by one of the big trans-Pacific liners leaving Japan. For several nights following the messages were heard plainly. Then came a lapse, and nothing was again picked up until the vessel was close to Honolulu. This was simply a wireless "freak," due to a peculiar condition of the atmosphere. Such incidents are common at spark stations.

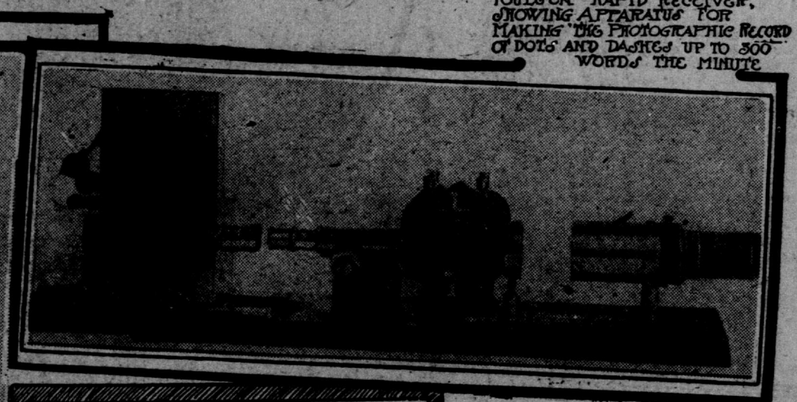
But meantime the Honolulu operator took messages from San Francisco without any interruption, which proves the steadiness of the Poulsen waves.

It was the old 300 foot poles on the ocean boulevard that did the first business with Honolulu. Some apprehension was felt by the builders over the giant towers of South City until communication was established with only half the antenna up. Finally came the eventful night when the new Federal station at Honolulu was able to talk for itself. The hour was just as Sunday morning turned. Then, according to previous arrangements, an 1,800 word news report was sent to it in blocks of 250 words, with an O. K. in reply after each block.

The next issue of The Call told the story.

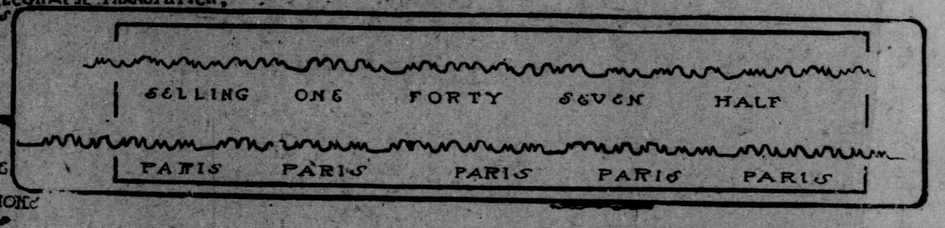


WIRELESS STATION AT SOUTH SAN FRANCISCO



POULSEN RAPID RECEIVER, SHOWING APPARATUS FOR MAKING THE PHOTOGRAPHIC RECORD OF DOTS AND DASHES UP TO 300 WORDS THE MINUTE

RAPID TELEGRAPH TRANSMITTER, WHICH SENDS OUT 300 WORDS A MINUTE FROM THE TAPE



PHOTOGRAPHIC TAPE WITH TRANSLATION