MARCONI
Pioneer of Radio

Douglas Coe

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By DOUGLAS COE

Illustrated by KREIGH COLLINS

Youngest son of a well-to-do Italian father and a warm-hearted, witty Irish mother, Guglielmo Marconi might have been a spoiled and idle young man. But, fired by visions of electric waves around the world, he deliberately chose the hard and exacting life of a scientist.

And it was this man who, more than any other individual, was responsible for that scientific wonder—radio—we now take for granted.

To cite some examples: the far-flung short wave broadcasts that seem so remarkable today, were the subject of Marconi experiments in 1896; the radio compass, which enables today's ships to calculate their position no matter how impenetrable the fog or night through which they travel, was designed by Marconi many years ago; and when today's airplane pilots "ride the beam," they are following an invisible micro-wave pathway which Marconi perfected.

It is true that Marconi's first stuttering spark, crackling from an awkward homemade apparatus to send a message the length of an attic work-room, is a far cry from the precision of today's radio broadcasting. It is also true that Marconi was not the first to send wireless waves the length of a room. But it was Marconi's rare combination of vision and practicality that transformed the spark's aimless stuttering into an orderly succession of dots and dashes—and saw in that first step the vision of music and conversation encircling the globe.

This splendid research and coordination of material on the part of Douglas Coe now brings us a really comprehensive life story of the man.

Complete with diagrams of Marconi's inventions, etc.

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About the Author:

DOUGLAS COE is a crystal set veteran. He doesn't remember how much oatmeal he made his mother buy so that he could wind coils on the empty round boxes, but he thinks it must have been a great deal. He also says that if he had known as much about Marconi in 1922 as he knows now, he would have saved a lot of the money he spent buying galena crystals—because he would have known that there were a lot of things lying around the house that would have served just as well.

But even before the days when Douglas Coe sat up half the night with earphones on his head trying to get Chicago or Fort Worth, he enjoyed having his hands (his face and neck, too) in the innards of Model T engines, electric generating plants, and electric water pumps. His father installed that kind of equipment and Douglas usually managed to find something to do on each job.

He helped earn his way through college by working as a repairman in an electrical appliance and radio shop, where he enlarged his mechanical experience to include washing machines, electric refrigerators, and oil burners. He had started out to be an engineer but decided to become a writer instead, and changed his engineering course for journalism.

Since his graduation he has been writing and photographing one thing or another, but he has managed occasionally to find the time to get his hands dirty on an engine or a motor or, as he says, "anything that turns around." He also admits that this biography would have been finished much earlier if he hadn't stopped to duplicate some of Marconi's early equipment just to see it work.

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CHAPTER ONE

A BOY AND A SPARK

"Do you want to come for a ride?"

"What?" Young Guglielmo Marconi looked up blankly at his elder brother, Alfonso. "A ride? No, I—not right now. Thank you very much," he added politely.

"Well then, do you want to—?" But Guglielmo was no longer listening to him. He was buried again in his book.

Alfonso's good-natured face puckered in irritation and he marched off to find his mother and father.

"I asked him," he said, "like you told me to. He didn't even hear me at first and then he said 'No, thank you very much.' " He mimicked young Guglielmo's polite voice.

"That boy!" his father fumed. "Always stuck in the library. What he needs is fresh air and—and exercise. Annie, can't you do something with him? Alfonso is good enough to offer to take him riding, but no—he can't be disturbed. What sort of child is he, anyhow?"

The Signora Marconi's soft Irish voice answered pa-

cifically. "But Giuseppi, we shouldn't urge the child. He's very studious. Perhaps we should leave him with his books."

"Studious! Hmm. His tutor's reports are not exactly encouraging. He doesn't seem too studious when it comes to figuring out how fast a train is traveling when it—well, whatever trains do in those problems of his."

"Guglielmo has great powers of concentration," Annie said firmly. She was fairly accustomed to this role of defending young Guglielmo, but sometimes even her Irish wit could not find the answer for her practical-minded husband's complaints. "He has great powers of concentration. It is a remarkable trait and I think we ought to encourage it—not always insist that he rush out riding or playing games."

"So he has. Or so you always tell me. But what does he concentrate *on?* That's what I'd like to know. Not his lessons, not—"

The Signora Marconi couldn't answer that question. She too sometimes wondered what it was that occupied her youngest son's mind when he sat absorbed for hours at a time over a book, or simply staring into space. But she was the self-appointed buffer between the young Marconi and the world, and she was adept at side-stepping such situations. "I'll go and speak to him myself," she said quickly.

Guglielmo was still just as Alfonso had left him, his slender body curled into a big chair, his blue eyes fixed on his book.

"Yes, Mother?" He and she always spoke English when they were alone together, and it emphasized the close bond there was between them. Sometimes they seemed almost in a little world of their own inside the Villa Grifone.

"We don't think it's wise for you to be indoors so much." His mother brushed the light hair back from his forehead with a gentle hand. "Alfonso is very kind to offer to take

you with him. After all, he is nine years older than you. You should be flattered to go riding with a young man of nineteen. Come now—won't you go outdoors for a while? Perhaps you'd rather fish or—"

"Fish? Yes, I'll go fishing." He gave his mother a quick smile, put down his book and went out to find Alfonso. And a few minutes later the boys were in a small boat, their eyes on the two lines dropped into the water.

"How pleasant the hills look in the sunshine," Guglielmo said cheerfully.

"Shh. You'll disturb the fish."

And Guglielmo fell silent, smiling to himself. This was always the best way out, when they urged him too strongly. When one was fishing one was supposed to keep quiet. And who was to know if a small boy were concentrating on the water or on his own thoughts? No, fishing was not so bad.

And now, let's see—what was it he had been reading about when his mother came in? Oh, yes—

Back in the Villa Grifone the Signora smiled at her husband.

"There, you see. He went fishing. He's really a very good boy."

"I never said he wasn't *good*," Giuseppi muttered. And then he smiled back at her. No one could help smiling at Annie Jameson Marconi. She had a way with her.

Giuseppi, hard-headed businessman that he was, had noticed it when he first met her. She had been a young girl then, the daughter of a wealthy Scotch-Irish family, and she had come to Bologna to study music at the Conservatory. She thought Italy was a beautiful place, full of music and color and romance. She was, in fact, hardly the sort of person one might have suspected Giuseppi of falling in love

with. Even Giuseppi was surprised. Romance? Why, he was a solid mature widower, with a son, Luigi, by his first marriage, and a farm and banking interests to look after. He had neither time nor inclination for such fancies. But Annie's Irish sparkle, and the Irish roses in her cheeks, and that little way she had with her— Giuseppi fell under its spell. And Annie, on her part—well, she had always thought Italy was romantic. Here was her own romance.

Alfonso was born the first year of their marriage; and nine years later, on April 25th, 1874, Guglielmo was added to the little family.

"What big ears he has!" That's what people all said when they first saw the new baby. Immediately afterward they remembered their manners, of course, and added that the shape of his head was fine, and that he looked healthy and intelligent. But that first instinctive comment had popped out before they could stop it.

The ears *were* big. And they were going to hear important things. They were going to listen to the first faint click that meant a miracle had happened. They were going to listen for the crackle of an electric spark across the wide Atlantic. So perhaps it was just as well that they were of good size and well formed—though none of the visitors who remarked on them so spontaneously ventured to predict their amazing future.

The Marconis were living in Bologna at the time, in the heavily-shuttered old Palazzo Marescalchi on the Via Tre Novembre, near the city hall. But shortly afterward they moved out to the more cheerful Villa Grifone at Pontecchio, near the city.

The Villa was a wonderful place to grow up in. It was set among lovely gardens, and a fountain made music under

its windows all day long. There was always something to see and investigate. And the little Guglielmo found the peasants of the estate always willing to answer his questions and to let him tag along when there was something especially interesting under way.

When the child was three the family made a visit to England. There they lived in an old house on the outskirts of Bedford, about fifty miles north of London—the Colleorton Villa, mentioned in all the guide books because it had been the home of a very famous man.

"John Bunyan lived here," the Signora Marconi told her son. "He wrote a very great book—'Pilgrim's Progress.' You must always remember that you have lived in his house."

"Yes, Mama." But Marconi didn't remember. He didn't remember anything about the visit at all. Because when a boy is three a house is a house and a garden is a garden, and he doesn't care very much about anything else.

Back home in the Villa again life went peacefully on. In the spring there was one thing to do, in the fall another—but there was always something. And whatever Guglielmo did he did with a great intensity; he might not stick at it very long, but he was very much absorbed at the time.

When he rode into Bologna with one of the peasants or with his father he listened enraptured to the fascinating stories that were part of the old city's history. One of his favorites was about a nameless hero who was "too fat to fight but keenly alert to the tortures of hunger."

"He wanted very much to do his part, when all the soldiers of the city were marching out to save it from the invading Milanese," said the old peasant, as he and Marconi sat comfortably behind a fat horse on their way home one day. "So do you know what he did?"

"What?"

"Well, he had a very good idea. He mixed up beef and pork and veal, and seasoned them well with a dash of this and a dash of that, and then he stuffed the mixture into the intestines of a pig."

"Of a pig?" Guglielmo was fascinated. "But why? Why should he waste such good food?"

The storyteller laughed. "He didn't waste it—don't you worry. He tied strings around the long casing—one string here, then a little farther along another string. In between, the meat swelled the casing out. And the amount between each two strings was just what a soldier might want to eat for a meal. And there it was!"

"There what was?"

"Bologna! Surely you know bologna—the lovely meat sausage you like so well?"

"Oh, that!"

"Yes, that. It was invented hundreds of years ago, and very useful it was to those soldiers. They could carry the chain of links around their necks, and break off a piece whenever they felt hungry. Very handy indeed. Now everybody eats it, of course—all over the world," the old man added proudly. "And they call it bologna because it was invented right here. Oh, some famous men have been born in this town." And he patted the little boy on the head.

Yes, there were lots of stories to hear. And lots of things to see. Guglielmo liked to walk beneath the lovely archways that protected Bologna's sidewalks from the frequent rains and from the hot summer sun. He liked the many beautiful churches of which the city was so proud. And he felt a little thrill of excitement when he stood in front of the leaning towers. Garisendo and Asinelli. Asinelli was the taller and

it leaned only very slightly; but stubby little Garisendo leaned so far in the opposite direction that it made the pair of them look like two bad friends who were trying to get as far as possible from each other. Suppose one day one of them—Garisendo, it would probably be—leaned a little bit further and suddenly—crash!—came down in a shower of crushing stones and rubble right on top of a small boy. Guglielmo had inherited a vivid imagination from his mother's Gaelic forbears. Sometimes he had to walk past the leaning towers rather quickly, with little glances over his shoulder to make sure they stood upright until he got safely away.

But it was all interesting. In fact, there was so much to see and do that Marconi failed to understand why his mother got a tutor for him when he was five. Who wanted to bother with lessons? Why couldn't people just let you wander around and find things out for yourself?

But it seemed they couldn't. So the lessons went on, not too satisfactorily, and Guglielmo grew older and a little wiser. And suddenly he realized that learning to read had opened a whole new world to him. Exploring a book, to his amazement, was as exciting as exploring the garden. Almost overnight it became his favorite occupation, and he had to invent excuses for staying indoors in the library when other people thought he should be outside.

Because the winters in Bologna were rather severe the family, out of deference to the Signora's delicate health, spent the most unpleasant months of the year in some warmer place—usually Florence or Leghorn. And it was this habit of migration which created the opportunity for a very exciting event. Up to the time Guglielmo was fourteen the tutor had traveled with them, so that lessons went on faithfully no matter where the Marconis were staying. But that

year Marconi enrolled in the Institute Cavellero of Florence instead, and he had classes in physics and chemistry.

It was those classes that were the excitement. Almost from the first day they absorbed Marconi's mind completely. This, he suddenly knew, was what he had always been looking for. This was the sort of thing he wanted to know—*must* know.

And from that time on Giuseppi never again needed to wonder what it was his youngest son was concentrating on. From that time on it was clear to all who knew him that Guglielmo was living and breathing the wonders of science.

The next winter, at Leghorn, there was the Leghorn Technical Institute, and Marconi was an enthusiastic if somewhat erratic student. He didn't want to bother about a course that had no bearing on physics or chemistry; but even mathematics (now that he no longer had to worry about those stupid trains traveling at unusual speeds from one point to another) had suddenly become bearable. Leghorn was a seaside town, with all the charms of the Mediterranean set forth for him to enjoy, but the dim rooms of the Institute lured him more compellingly than any beauties of shore or water.

The Signora Marconi, who had always known that Guglielmo would come into his own one day, was very happy for him. There was still the little problem of fresh air and exercise, but she tried not to nag him too much about that. In fact it was through her influence that the well-known Professor Vincenzo Rosa agreed to give the boy private lessons.

Marconi was overwhelmed when the great man said to him one day, "This interests you very much—the study of physics?"

"Oh, yes, sir. Very much."

Professor Rosa glanced at the boy's notebooks, smiled

gently over the awkward little drawings illustrating experiments, and then said, "Perhaps you would like to study with me a little, yes? Just the two of us together, seeing what we can find out about these mysteries?"

"Oh, Professor Rosa! Could we? Would you? I mean—"

If the man had doubted whether lessons for so young a student would be worth his while, he was convinced from that moment. If the boy could look like that at the mere suggestion of learning more about a subject—well then, at least one would never have to keep at him, to waste one's time urging him to study.

From then on when the family was at home, Marconi spent hours in the library of the Villa, grateful for the really fine collection of technical books it offered him. But even so they were too few. He subscribed to technical journals, made dozens of his scrubby little drawings, and even attempted amateurish experiments of his own.

One day he read that Benjamin Franklin had written to the Royal Society of London in 1750, suggesting that "electrical fire might be drawn silently out of a cloud before it came nigh enough to strike." And immediately Marconi set to work to erect a spear-like zinc apparatus on the roof of the house. Inside it was connected to a bell-ringing mechanism. And then for days he annoyed the family by inquiring at intervals how soon they thought it would rain. "Not just one of our little showers," he explained urgently. "It must be a regular thunder storm."

"Why must it? What do you want a thunder storm for? It would hurt the crops," Giuseppi Marconi finally said, his patience exhausted. Guglielmo had the strangest tastes. It was all a man could do not to scold him heartily once in a while.

But the storm came, finally. The thunder reverberated

from the low hills and the lightning flashed satisfactorily across the blackened sky.

Marconi was in a fever of excitement. His clothes were wet and his mother feared that he might catch a cold; but oblivious to everything but the success of his experiment Marconi tore back and forth between the roof and his bell inside. And sure enough, it worked. When sufficient static electricity had been collected by the apparatus on the roof, the bell actually jingled! He heard it. And Alfonso and Luigi and his mother and father had to admit that they heard it too. They were a little puzzled as to why Guglielmo should be so excited over the event, and suddenly, in the midst of his enthusiasm, Marconi wondered too.

After all, what had he really done? Nothing so very remarkable. Perhaps he never would. Because he knew so very little, and there was so much more to learn. Doggedly he returned to his books.

And so four more years went by. The winters were spent at Leghorn or Florence, the other months at home. And Marconi made two new friends. At Leghorn his brothers and his fellow students noticed that young Guglielmo, usually so wary of friendship, spent long hours leading an old blind man through the streets, talking to him animatedly.

"Where did you ever find him?" Alfonso wanted to know. "And who is he, anyway?"

"Why, he knows the Morse code," Marconi answered, as if that were reason enough to set a man apart from more ordinary creatures.

"But he's blind, isn't he? I mean—don't you get tired helping him around all the time? Why didn't you come out in the boat with us yesterday, if you didn't have to study?"

"But I told you." Sometimes Guglielmo thought Alfonso

was difficult to understand. "He used to be a telegraph operator—and he's teaching me the code! Think of it! Why, I know almost all the letters already."

Alfonso shrugged. Very often indeed he thought his young brother was difficult to understand.

The other new friend was a neighbor of the Villa Grifone—the famous Professor Augusto Righi of the University of Bologna. Righi's curiosity about this solemn-eyed boy had been aroused when he began to hear of the little experiments he did, and of the long tireless hours he spent with his books. Not an ordinary young man at all, Righi thought, rubbing a thoughtful hand over his short pointed little beard. And so he visited Marconi and talked to him, and invited the boy to his own laboratory. Yes, he had been right. In spite of the boy's youth he found himself speaking to him with patience and respect. He was ignorant, of course, but he was tremendously eager to learn, and he had a surprising little trick of intuition—he sometimes understood quite perfectly things which his actual knowledge was too meager to make clear to him. Strange. And interesting.

Friends and books—two valuable things Marconi had. But he had another too—he had the time to study. If Giuseppi Marconi had not been so well-to-do Guglielmo might have been faced with the problem of earning a living, but the shrewd business head of the elder Marconi had made that unnecessary. The Marconi boys could do pretty much as they liked. But since another boy, in Marconi's place, spoiled and pampered by a wealthy family, might have liked to do something very different and much easier than the tasks which Marconi set himself, it is important to point out that Marconi had still something else—and perhaps the most important of his possessions. It was the will to work tirelessly.

It is inspiring always to hear of a boy or girl fighting against the heavy odds of poverty to achieve success; it is almost as inspiring to hear a story such as Marconi's—of a young man who might have applied himself to pleasure, but who chose the difficult road of science instead.

In the summer of his twentieth year he went with Luigi for a vacation to Biellese in the Italian Alps. Perhaps, his mother reasoned, in the beautiful mountain country and with only his gay spirited half-brother for company, Marconi would take a real vacation. It would be good for him to forget his books for a while.

It is not known how hard he tried to forget them, nor with what patience Luigi coaxed him out to climb rocky slopes in the bracing air. Maybe he grew tired of coaxing. Maybe he was impatient more than once with the pig-headed young man who behaved as if there were only one really interesting thing in the whole world.

But one thing is known. Up there in the mountains, with the whole outdoors to tempt him, he picked up a technical journal one day. And in it he read an article that changed his whole life and the life of the world.

The article was an obituary account of the scientist Heinrich Rudolph Hertz, who had died in January of that year. It told something of the man's work, and described what are known as Hertzian waves. And it related how Hertz had discovered that tiny sparks occurred in the gap of a loop of wire at one side of a room, when the scientist had radiated electro-magnetic waves with an electric oscillator at the other side—although there had been no connecting link between the two pieces of apparatus.

But—! Marconi's eyes opened wide. But if he could do *that—!*

Carefully he read the piece through again. He could hardly believe his eyes, but it was true: Hertz had gone that far and then he had stopped.

Marconi told himself that it must be only his ignorance which made him feel so excited. There must have been a very good reason why Hertz did not utilize that information in the way which he himself thought it could be utilized.

But he could not discourage himself. He had something—he knew it! If Hertz could do that much then he, Marconi, could do more: he could transmit intelligence through the air, without connecting links, just as Hertz had transmitted his spark.

He could do it and he would. Somehow.

When Luigi called to remind him that it was time for dinner Guglielmo didn't even hear him. He was on the track of his miracle.

CHAPTER TWO

BACKGROUND FOR A MIRACLE

MARCONI SETTLED down to put in order all that he knew about electric wave transmission. It was not a great deal, of course, because in those days the whole subject was still very much of a puzzle to the wisest scientist. A quantity of research had been done, but its significance was sometimes unrecognized by contemporary workers in the field. And although many men were concerned with the problem at the very time when Marconi read that article in the Biellese mountains, few were interested—as Marconi instantly became—in the practical application of the knowledge they were carefully compiling in their laboratories; their study

was directed toward the establishment and proof of theories, rather than their usefulness for everyday life.

As early as 1678 a Dutch mathematician, Christian Huygens, had suggested that light might be the result of the rapid vibration of *ether*—the name given to the odorless, tasteless, invisible substance believed to fill all the available space in the universe. But the first real surge in what might be called the advance of wireless telegraphy—long before it was called that—came with Michael Faraday, that amazing electrical genius born in England in 1791.

Faraday, the son of a blacksmith, had a meager schooling which was interrupted when he was thirteen in order that he might go to work. As an errand boy in a bookshop, and later as an apprentice to a bookbinder, he encountered a few kindly intelligent men who encouraged him to study, and gradually his interest was centered in science. One of those men took the trouble to see that the boy was permitted to attend a course of lectures by the great Humphrey Davy, the most brilliant British chemist of the day. Faraday took 386 pages of carefully written notes on those lectures, and illustrated them by drawings meticulously done. And not long afterward Davy, impressed by those notes and by young Michael's fierce earnestness, took him as his assistant in the Royal Institution.

Thereafter Faraday's devotion to his work was almost fanatical, and his knowledge and importance increased until he was admittedly the outstanding scientist in England. He gave many series of lectures at the Royal Institution—including a series of talks for young people, considered a great novelty at that time—and strikingly enlarged the world's fund of information in several directions. His greatest invention was probably the dynamo, or generator.

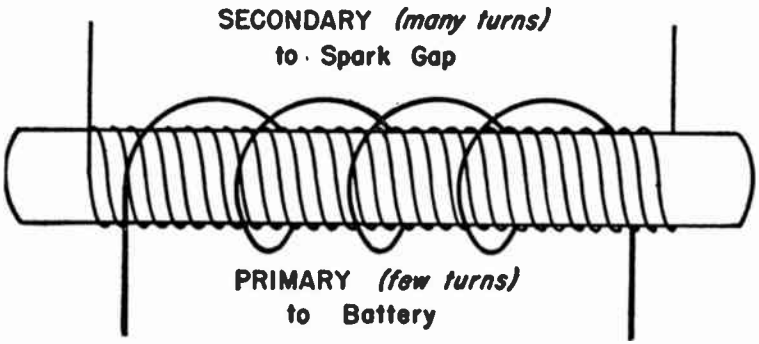
But it was in 1832 that Faraday, carrying forward the Huygens vibration, or undulation, theory, wrote in a letter: "I cannot but think that the action of electricity and magnetism is propagated through space in some form of vibration."

This statement came to the attention of one of Faraday's contemporaries, a jolly, humorous young man named James Clerk Maxwell. From his earliest childhood Maxwell had been curious about all manner of physical facts, and he was chiefly fascinated by light and color. He claimed his earliest recollection was of looking up at the sun and "wondering." His schoolmates called him "Dafty" because he wore strange clothes, spoke with a Galloway accent—his father was a Scottish laird—and made peculiar remarks. But by the time he was fifteen well-established scientists were beginning to take a real interest in those remarks, and for the rest of his comparatively short life—he died at the age of 48—he was an original and productive student in the field of physics. His principal contributions were not conceived in the laboratory, but were worked out in the form of mathematical formulae; it was by means of a formula that he proved definitely, in 1867, that light waves were similar to electro-magnetic waves, and that both light and electricity traveled through the air at the speed of 186,000 miles per second.

Faraday, in the meantime, unwittingly made another contribution to the wireless telegraph which he was not to live to see: the induction coil. He discovered that if he wound a few turns of wire around an iron bar, or core, and then on top of those few turns wound a second coil of very many turns, this simple contraption was in reality an amazing device.

Because if, from a small battery, he sent a surge of low-

voltage electricity through the small coil, there resulted a surge of high-voltage electricity from the ends of the large coil. With this high-voltage current he could make sparks—huge sparks! And it was with sparks that Heinrich Rudolph Hertz later succeeded in sending electric waves hurtling through the air at their inconceivable speed.

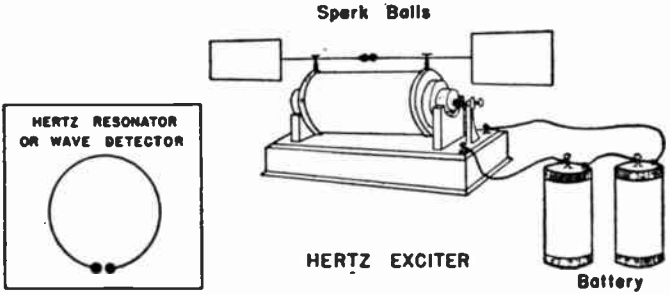


INDUCTION COIL

Hertz had been born in Hamburg in 1857, and when he was twenty he went to Munich to learn to be an engineer. But soon he found himself so interested in physics that he moved on to Berlin to study at the University there, and was shortly recognized as an unusually gifted student and permitted to undertake original research. He became known as the best pupil of the famous Hermann Helmholtz, founder of the Helmholtz theory, and won many prizes. At the age of 26 he was made Professor of Theoretical Physics at Kiel University, where he studied Maxwell's theories and made his own astounding discovery.

One day during a lecture, while he was demonstrating an experiment with the so-called Leyden jars, used for the

storing of electricity, he noticed that if he discharged the electricity collected in such a jar through a small coil in which there was a tiny gap, another similar coil near by but not connected by any wires to the first coil, also exhibited the presence of electricity. At first nonplussed by what seemed to him an accident, he finally came confidently to believe that the small spark he had noticed jumping the gap in the first coil, had caused the presence of electricity in the second coil. He decided to do more experimenting with sparks, and turned to Faraday's induction coil as the source of larger ones.



He constructed a device he called an "exciter," consisting of an induction coil, with metal balls attached to the ends of the high-voltage coil. Rising out of each ball was a rod terminating in a metal plate. It was his theory that when the high-voltage current caused a spark to leap from one ball to the other, electric waves would be generated and discharged into the air through the metal plates.

To prove this he constructed a wave detector, or resonator, out of a wire bent into a circle, with a small gap where the ends did not quite meet and tiny metal balls on those ends. He held this detector near his exciter, and then caused a spark to flash across the discharge balls of the induction coil. Immediately another small spark was seen to jump across the

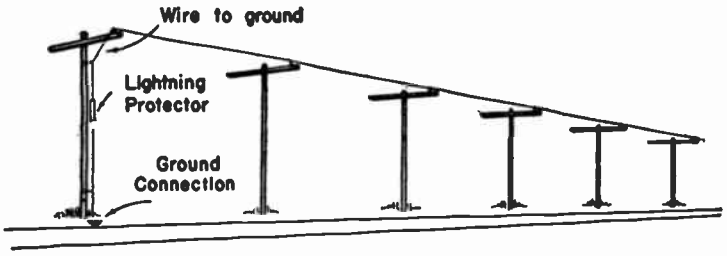
open ends of the detector. The waves had been created, had leaped across the intervening space between the two pieces of apparatus, and had been unmistakably detected in the second!

Hertz had confirmed the Maxwell theory that electromagnetic waves travel through the ether. Then he went further and proved that Maxwell had been right in his assumption that electricity and light travel at the same speed. Thus these two men—Maxwell working entirely on paper, never constructing a single piece of equipment; and Hertz working in the laboratory—came to the same conclusion. Electrical waves could be made to travel through the air, and those waves could be detected. Hertz continued the study of his waves—which came to be known as Hertzian waves—until his early death at the age of 37.

From yet another source came a further thread of the research that was to culminate in wireless. In 1866 S. A. Varley, working in England, was searching for a device that would protect telegraph lines from the devastating effects of lightning. Too often for the efficient operation of the telegraph system, the vivid flashes that splinter the sky during an electrical storm would strike the overhead wires of the lines and, seeking a path to the ground, shatter insulators, poles and wires in their furious dash to the earth. The obvious solution, Varley reasoned, was to discover a method for permitting the lightning to reach the ground before it had a chance to wreck the lines, and the simplest way to do that, of course, would have been to connect the wires themselves to the ground; but that would have allowed the electric impulses that operated the telegraph to leak off into the ground also. Somehow he must find a way of grounding the lightning without causing a loss of the telegraphic electricity.

In the course of his research Varley had discovered a strange property of loosely packed carbon and tin filings. These minute particles would not ordinarily serve as a conductor of electric current, but if lightning flashed near by, the filings immediately clung together and formed a fine conductor. It is interesting to remember that in 1850 the scientist Pierre Guitard had noticed that when dusty air was electrified, the dust particles in it seemed to cohere into little clusters or strings. Guitard did not understand the phenomenon he had observed, and neither did Varley understand why his filings should cling together in this manner; but Varley, unlike his predecessor, did realize how he could utilize his discovery.

He proceeded to connect the overhead telegraph lines to the ground, at intervals, through pieces of wood. Each piece of wood had a hollowed-out chamber in the center of it, and the chamber was filled with the carbon and tin filings. When lightning struck the lines, the little granules clung together and formed a bridge over which the devastating current could pass harmlessly into the ground. But since he had also



VARLEY'S LIGHTNING PROTECTOR

discovered that after a few minutes the filings would loosen up again, and cease to serve as a conductor, the telegraph current was thereby prevented, as soon as the danger was past, from following the lightning into the earth.

Varley could not have known at the time of his discovery that it was the presence of electric waves which caused the carbon and tin filings to adhere to each other, because Hertz had not yet found that a spark—or lightning, which is after all only an enormous spark—generated electric waves. But Varley's device was remembered after the publication of Hertz's theory, when scientists all over the world began to look for new and better means of detecting electric waves.

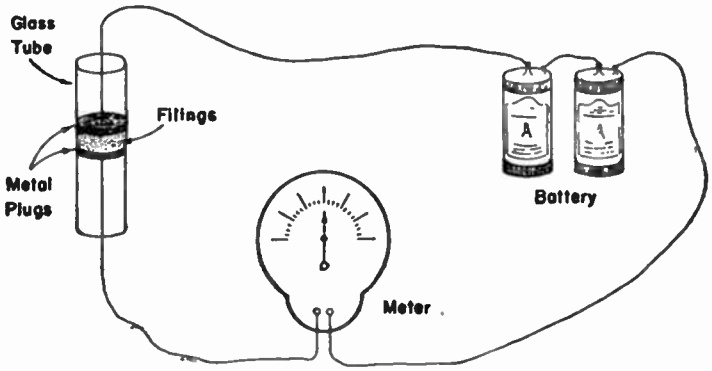
In 1878 the Englishman, Professor David E. Hughes, had made a further contribution to this growing fund of knowledge. Hughes was, according to Sir Oliver Lodge, a man who "thought with his fingers." He had emigrated to Virginia with his family in 1830, and attended St. Joseph's College in Kentucky; later he went to Paris, where much of his work was done. Although many of his inventions were to be acknowledged by praise and the payment of huge sums of money, Hughes also performed some experiments for which he won little acclaim. One of these was his discovery that the discharge of a Leyden jar had the same effect on loose filings of zinc and silver as lightning had had on Varley's tin and carbon filings. The Hertzian waves were still unknown, and so the announcement created little excitement at the time; but later on, his work, like Varley's, was brought to light and utilized.

Professor Calzecchi Onesti, an Italian, working along similar lines, in 1884 published an article in *Il Nuovo Cimenti*, claiming that copper filings reacted by clinging together when they were subjected to a high-voltage discharge of electricity. And six years later Professor Edouard Branly brought forth his famous filing-filled glass tube, the best and most sensitive detector up to that time.

Branly, a gentle self-effacing Frenchman, was born at

Amiens in 1844, and educated at the Lycée de St.-Quentin, and later at the Lycée Normale Supérieure in Paris. In 1873 he took his Doctor of Science degree and became Professor of Physics at the Catholic University of Paris, a position he continued to hold until he was a very old man. In 1927 he said of himself with quiet humor, "My difficulties have always been tremendous. I have never been well off and so have always lacked appliances. That forced me to study medicine and earn a living as a doctor. Of course, it has helped me, and by making others well I know how to look after myself."

When Branly had perfected his version of the filing-filled device, he connected a meter to a battery—the connecting wire passing through the tube—and used this apparatus to experiment with Hertzian waves, in which scientists were vastly interested by then. In their normal, or loose state, the filings did not permit any current to pass through the tube, and the meter's pointer remained at zero; but if he created



BRANLY'S COHERER CIRCUIT

a spark near by, by means of a Hertz exciter, the filings clung together and the current from the battery would be registered by the meter's pointer. When the spark ceased, the

current continued to flow through the tube for a short time until the particles of filings loosened of their own accord. Then Branly discovered that by tapping the glass tube when the spark had stopped flashing, he could loosen the particles instantaneously and cut off the current to the meter. Although he did not realize it, this experiment brought him very close to wireless telegraphy. In fact there are people today who claim that Branly, because of this combination of the filing-filled tube and the Hertz exciter, should be given credit for inventing wireless telegraphy. Branly, who lived to see Marconi become famous and always spoke generously of his work, emphatically denied such claims.

In 1894 Sir Oliver Lodge, the eminent British scientist, using much the same equipment, succeeded in detecting Hertzian waves at a distance of several hundred feet from the Hertzian exciter. The son of a potter, Lodge had been born at Penkhull, near Stoke-on-Trent, in 1851, and had been taken into his father's works when he finished school. He was already a successful potter when he happened to read some old copies of *English Mechanics*. Instantly his interest was aroused in the subjects of engineering and science, but it was seven years later before he persuaded his father to let him enter University College, London, where he finally took his Bachelor of Science and Doctor of Science degrees in 1881. He was elected the first Professor of Physics and Mathematics at Liverpool University in 1897, and in 1900 was chosen by the Crown as the first Principal of Birmingham University. Two years later he was knighted.

Lodge's experiments were numerous and important. When he first performed the 1894 demonstration with the filing-filled tube and the exciter he, like Branly, had to tap his tube to loosen the filings; but by the time he repeated his experi-

ment in Oxford, in September of the same year, he had fitted his tube of filings with a clockwork mechanism which automatically jarred the particles loose as soon as the spark stopped flashing. He was also able to demonstrate that a spark of long duration made the meter's pointer swing much farther than a spark of short duration. The name he gave to his improved mechanism was descriptive of the action of the metal filings: he called it a coherer.

It is interesting to recall that Lodge had with him on the evening of his public experiment at Oxford a Morse telegraph ticker, which he could have connected to the battery in place of his meter. Had he done so this would have been the first instance of actual transmission of messages by wireless. Sir Ambrose Fleming, inventor of the radio vacuum tube, referring to that evening in an address before the Royal Society of Arts more than forty years later, said:

> He had on his table a Morse inker (so he tells me) and could have used it with a sensitive relay to print down the signals, but as he wished the audience to see the actual signals he preferred to use the mirror galvanometer. It is therefore unquestionable that on the occasion of his Oxford lecture in September 1894, Lodge exhibited electric-wave telegraphy over a short distance.

Wireless was on its way—in fact, it had actually arrived, although no one recognized its presence at the time. Lodge himself made no attempt to carry his work from the theoretical to the practical field, and, considering the date of his experiments—the very year of Marconi's trip to Biellese—it is doubtful if the young Italian heard of them. Lodge himself wrote in *Wireless Weekly*, September 26th, 1923:

> I was too busy with teaching to take up telegraphic or any

other development, nor had I the foresight to perceive what has turned out to be its extraordinary importance . . .

In far-off Russia another thread was being spun that would eventually be picked up by Marconi, though it was created a year later than the fateful summer of 1894. Alexander Stepanowitch Popoff, born in 1859 at Bogosloosky Zawood, in the Urals, persuaded his father that he did not want to be a priest and, despite paternal disapproval, entered the University of St. Petersburg. It was while he was teaching at the Torpedo School in Kronstadt that he discovered a new use for the coherer: he found that it could foretell approaching lightning storms. This, of course, was closely akin to Varley's use of the loose metal filings. Popoff, however, was not satisfied even with Lodge's improved version of the coherer. He wanted something better than a clockwork mechanism to tap the tube, and he desired some device that would make a noise to warn of the nearby storm. He therefore substituted an electrical bell for the meter Branly and Lodge had used, and allowed the bell's striker to hit against the coherer tube. Then, when a lightning discharge took place off in the distance, the coherer passed current from the battery to the bell, the bell striker began to vibrate, and the bell rang. But at the same time the striker was jarring the coherer tube, so that the instant the flash of lightning was over the particles de-cohered, the flow of current stopped, and the bell fell silent. When another flash occurred the same sequence of action took place.

Now finally the threads were all there. The scientists who worked before Marconi had spun well. Faraday had declared that there were such things as electro-magnetic waves, and Maxwell had proved their presence mathematically.

Hertz had designed a machine for making them. Varley, Onesti, Hughes and Branly had invented and improved the means for detecting their presence, and Lodge and Popoff were continuing that work.

What was needed was a man who would translate all this theoretical knowledge and laboratory experimentation into a practical system of communication—a man, first of all, with vision enough to realize that such a system was the possible, even the inevitable, outcome of all that had gone before; a man willing to devote his life to the task of transforming the tiny laboratory spark into a giant capable of leaping the widest ocean, and being detected on the other side.

What was also needed was a man who would be able to open wide the door of the laboratory, strip the mystery from electric wave transmission, and make it into a tool for everyone to use—the butcher, the baker and the candlestick maker.

High in the Biellese mountains young Marconi sat transfixed, a magazine on the floor beside him and a sheaf of notes under his hand. When Luigi called to remind him that it was time for dinner Guglielmo didn't even hear him.

CHAPTER THREE

THE SPARKS BEGIN TO FLY

ALL THE rest of that summer Marconi lived with his dream. He read everything pertaining to electricity and electromagnetic waves that he could lay his hands on in that mountain retreat; he sat for long hours musing about the potentialities of the Hertz exciter and the coherer with its little self-tapping mechanism; and he drew dozens more of his awkward, youthful diagrams.

When the vacation was finally over he hurried gratefully home to beg from his mother the use of the two big rooms on the third floor of the house. He must have them for his very own, he explained; it must be understood that he was not to be disturbed, and no other member of the household was to be allowed to enter his domain except by invitation.

"Not even to clean for you?"

"Not even to clean." He smiled at her. "It doesn't matter if they get dirty."

Did the Signora Marconi say to herself "This is it—now he will do the great things I have always expected of him?" or did she think his request the whim of a mere boy who would have forgotten all about it before she had had a chance to get the rooms ready for him? At any rate she agreed, helped him with his arrangements, and watched as he carried up to the big bare loft-like space all his books and reports, quantities of wire and bits of apparatus. And then she set herself to guard his privacy.

"No, no. You mustn't disturb him now. I'll see that he gets the message when he comes down." "We shall go ahead with our dinner without him, Giuseppi. I can have a tray sent upstairs to the boy."

Days lengthened into weeks and her self-imposed task continued. Soon she could be sure it was no whim. Guglielmo was a man now in the seriousness of his purpose. And before long she found herself worrying again. Surely now he was too serious. Those long weary days in the attic, those brief nights of sleep, those irregular meals—for sometimes he forgot the tray of food even when she herself had placed it at his elbow—they could not be good for him. But she disciplined herself as sternly as her son did. There were people to whom an idea was more important than rest and food and pleasure, and if Guglielmo were one of those rare men—

"No, please, Giuseppi. Don't be impatient. I'll slip up myself and tell him how late it is."

And what was going on up in the attic all this time? Marconi was building his own exciter and his own coherer, about 30 feet apart. From the generous and kind Professor Righi he had discovered that better and more regular sparks

could be produced if the spark balls of the exciter's induction coil were immersed in vaseline, and so he did that. And he wired his coherer to an electric bell.

So far he had invented nothing new. He had attempted no improvements over the experiments of Lodge and Branly. He would be content if, at first, he could reproduce them. Perfectly aware, as he was to be throughout his life, of his own comparative ignorance, he preferred to take each step in his path slowly—to acquaint himself as best he could with the peculiarities of the electric waves.

It was a full month before he was ready to press the switch that sent current through the induction coil for the first time. The blue spark leaped between the brass balls and crackled in the still air.

But at the coherer end of the big room there was only silence. The bell had not sounded.

He touched the switch again. Still nothing.

What was the trouble? Was the theory perhaps entirely wrong? But that couldn't be so. Hertz had proved that waves could be radiated and detected at the distance of a few feet. Lodge had detected them as far as 200 feet from their source. The fault must lie in his equipment.

Patiently he started all over again, winding new coils, constructing a new coherer. There were no stores in those days where such apparatus could be purchased ready made. Everything had to be done by hand.

After a second month of heartbreaking work he was ready to test once more. In the hushed room he made a last-minute adjustment. And then his sensitive finger pressed the switch. The spark jumped. And this time, at the other end of the attic, the bell rang! Marconi had radiated his waves 30 feet and detected them clearly at that distance.

It was late at night, but sure of a welcome, despite the hour, he tiptoed downstairs to his mother's room and touched her on the shoulder.

"Mother, will you come? I want to show you."

The Signora Marconi was wide awake in an instant. A moment later they were climbing the stairs and then she was with him in the workroom.

"You stand right here, Mother, and listen."

He hurried to the far end of the room, touched the switch, and watched her face over his shoulder.

Yes, the bell rang. The Signora Marconi heard it. And although the mechanisms and principles involved were completely mysterious to her, and she had no understanding at all of why the bell-ringing was a triumph, she knew by the look in her son's eyes that it was. She told him he was very remarkable—very remarkable indeed. She had always known he would do something like this, she said. And then she added that he really ought to come to bed now; it was very late and it was getting cold.

Marconi smiled. "Yes, Mother. I'll come. I'm finished for the night. But—it is wonderful, isn't it? You see, there are no wires at all between my exciter and the coherer—that's where the bell is."

"It's *very* wonderful."

A few days later he was ringing a bell on the ground floor from a spark created in the attic. Marconi and wireless were on their way.

And now he needed money. He called his father to watch an experiment, and then he made his request.

Plump hard-headed Giuseppi watched and listened in silence. "Yes, yes. That is all very fine. You rang the bell.

I heard it. But of what practical value is all this nonsense? Bells can be made to ring quite simply by other means."

"Yes, Father, they can." Marconi nodded and smiled, remembering the story his father never tired of telling about himself. It concerned the beautiful Church of Saint Peter, Bologna's pride, and the group of public-spirited citizens who had banded together to collect money for its repair. Giuseppi was on their list of persons expected to contribute a goodly sum.

"The façade is in a serious state of disrepair," the chairman had explained carefully to the elder Marconi. "And of course the tower is in a dreadful condition. It needs a great deal of work. We know you will want to contribute to this worthy cause."

"Yes, of course. Of course." Marconi nodded solemnly to his visitors. "Naturally I want to help. Let me see. I shall give you—" Suddenly his eyes lighted. "I shall myself contribute the cross to surmount the tower."

The chairman swallowed. The cross would be tremendously expensive. "The cross! But Signor Marconi, are you sure that—I mean—"

Marconi waved his hand. They were not to thank him. It was nothing. And the fact of the matter was it had been nothing. His generous gesture had not cost him a single centesimo. For Giuseppi knew his fellow-citizens, and he had guessed correctly just how much they would accomplish. It had been years now since that committee had called upon him, but the façade of the church and the tower were still unrepaired. It had never been necessary to buy the cross at all.

Yes, Giuseppi was no fool when it came to money matters.

Too kind to be ungenerous, he was likewise too shrewd to throw his money away.

"Yes, Father, they can," Guglielmo repeated. "But what would you say if I told you that with this apparatus I could send messages over long distances—for many miles, perhaps?"

"I should say, my son, that you have inherited too much of your mother's imagination and too little of my common sense. I am a practical businessman, and if you were more like me—"

"But Father," Marconi interrupted gently, "all this apparatus of mine was invented by scientists, by men searching for truth in their laboratories. It is I who am trying to apply it to the business of the world—to put it to work for people everywhere. I think it takes a practical man to see in all these —these wires, as you call them—such a possibility."

The older man was silent for a long time, his eyes narrowed. Perhaps he had misjudged the boy. That had been a clever answer. But he must not jump to new conclusions too quickly.

"I do not say it cannot be done," he said cautiously. "But I do say that so far you have rung your bell no farther away than I could have shouted. What is the good of ringing a bell 30 feet away when a man can raise his voice and be heard quite clearly himself at that distance? Eh?"

"But—"

"I don't say I won't help you. I only say I'd like some proof that this scheme of yours might work. Show me something a little—well—"

"A little more exciting than 30 feet?"

"That's right. After all, 30 feet—"

They were smiling at each other now, with respect. And when his father had gone Marconi settled to work again. He

could have used the money immediately, but he saw Giuseppi's point of view, and he felt sure he could satisfy him.

Perhaps if the— He took the Branly coherer apart and began to redesign it to achieve a greater sensitivity. After endless tests he discovered that a mixture of 95% nickel and 5% silver made the best kind of filler for his tube, and he ground the particles of metal until they were fine as dust. Then he narrowed the slit in which the particles rested until a sheet of paper would fill it. As a final change he exhausted the air from the tube and found that the vacuum created made a tremendous improvement.

And then, daring greatly, he transferred his coherer to the lawn. Now it was much more than 30 feet from the exciter, but Marconi knew it would work. It had to. And it did.

Once more Giuseppi was called in to witness. Marconi pressed the telegraph key which he had substituted for his original switch, and on the lawn the coherer, now arranged to click like a Morse telegraph receiver, responded instantly.

"You see, Father? It—"

"It might be some trick of the atmosphere. A single little click like that could be caused by almost anything. Try a—I'll tell you—try the Morse code signal for the letter S. Three clicks, isn't it?"

Three times Marconi pressed his key. Three times the sparks leaped, and on the lawn the coherer clicked three times.

Marconi waited and after a moment his father smiled. "I believe it," he said, and the face of the Signora Marconi beside him glowed with pride. She had known all along that her son could do whatever he said he could do.

"And now, Father, there are many things I must buy. Wires, metal—"

"Not so fast, not so fast. Let us keep our feet on the ground. You say you need money. Very well. And I have money to invest. You have proved to me that investing it in your experiments might be wise. Might, I say. But it is my habit to understand the things my money will do. And I do not understand all this. Suppose you explain to me first how this machine of yours operates."

Concern showed now in the Signora's eyes. Giuseppi was making it too difficult. How could he, a banker, expect to understand these things? Guglielmo, of course, was a genius, and to him they were clear. But if it was necessary to make them clear to Giuseppi too—

"It is all so complicated," she said quickly. "For myself, I do not see the need for understanding the details. Isn't it enough that our son knows about them, and believes in this thing? Can't we have faith in him?"

Her husband patted her shoulder. "I can have faith, yes. But for a wise investment, faith is not enough. Eventually, if these little experiments are successful, large amounts of money may be necessary and our son may have to talk to the men who possess them. Those men, I assure you, will need more than faith. They will ask to understand and to be convinced. If I can be convinced—they might be."

Young Marconi smiled unwillingly. He knew that he was, as he had told his father, practical-minded. And because he was, he understood Giuseppi's point of view. Furthermore Giuseppi was right about the other men whom he might have to see in the future—in fact, his reference to them was a flattering proof of his own faith.

"Very well, Father. Have you time now? We shall begin to make you into an engineer."

The Signor Marconi settled his short plump form comfortably. "I have time. Begin."

His mother left them alone together. And when she had gone Marconi took a deep breath. "Scientists have believed for a long time," he began, "that the whole universe is filled with a substance that cannot be seen nor smelled nor tasted. They call it the *ether*. Finally one of them suggested that light is caused by a vibration of this ether—a very rapid vibration."

"What does a scientist mean when he calls something rapid?" Giuseppi was determined to keep this story in terms he could understand.

"They say some vibrations are so fast that one thousand million of them take place in a second."

"One thousand million! But no one could see them in that case."

"No, of course no one can see them. But men have proved their presence. Faraday believed in their existence years ago, and a mathematician in England, Maxwell, proved he was right—worked out a formula for them on paper."

"Hmm. On paper many things can be proved. But go on."

"Well, other scientists began to agree with him. And then there came a great man named Hertz, who found a way of making such waves—electric waves—with sparks."

"Ah! Now we are back at the sparks. And how do sparks make waves?"

For a moment Marconi was silent. Many men who had worked with electricity for years could not understand how that was done. How could it be explained to a man who knew nothing whatever of electricity? And then he saw the sceptical twinkle in his father's eyes and he knew he must try.

"Electric waves are like ripples on a pond," he began care-

fully. "If you throw a stone into the pond it creates little waves that widen out in all directions in great circles. Well, the spark is like a series of those stones. It disturbs the ether like a succession of stones thrown in the water disturb it."

"But wait. A succession? One spark is like many stones?"

"I told you that Professor Hertz was a great man. He realized that a spark is not a smooth stream of fire flowing from one point to another, but a series of incredibly rapid tongues of flame following one after the other. And each tongue of fire causes a disturbance in the ether—as if a rapid-fire cannon were shooting thousands of bullets or stones into a pond in quick succession."

"I see. I suppose they proved that on paper too."

"Yes, but I—I think I can explain it to you. These sparks jump very quickly, as I said. But let us think of one as if it were going very slowly. When the fire first leaps from one point to the other—from this ball to this ball, on the exciter—its heat causes a vacuum in the air, like a tiny hole. And since electricity cannot pass through a vacuum the spark is halted. But instantly air rushes into the little hole that has been formed in it, there is no longer a vacuum, and the flame can jump again because there is air present for it to pass through. Then once more it leaves a vacuum behind it—and this goes on and on as long as I make the electricity pass through the coil of the exciter. It is the sudden stopping and starting of the tongues of fire that disturb the air and create the waves."

Giuseppi nodded and after a moment he said, "Yes, I understand—well enough, at least. You explain clearly. But that is only the background of the story, isn't it? The sparks make little waves—yes; the scientists know it and now I know it. You even proved to me that they traveled from here to the lawn, a few hundred feet. But how do you know

they will go farther? And how far do you think they will go? What return would there be for my money—or anyone else's—if your machine proved able to function only for such short distances?"

Marconi sighed. He had done his best. He believed there was nothing to stop the waves from traveling miles and miles and miles. He had convinced Giuseppi of the presence of the waves; but could he convince him of the nothing? It was probably too much to hope for.

"If they travel for only a short distance, then—" he shrugged—"you are right; there would be no return for your money. And if I were to tell you that I can see a time when my little click can be heard across the ocean, you would not believe me. Perhaps no one would. But it can be done. The first small steps—those I have already taken. Last week 30 feet, this week 200 feet, perhaps next week a thousand. Then—?"

Giuseppi got to his feet. The boy was convincing. Last week it *had* been 30 feet, and this week it *had* been 200. And perhaps the banker had more faith than he liked to admit.

"When you have further progress to report I will be ready to hear it," he said, and Marconi's lips tightened. He told himself he had been prepared for failure, but— "And in the meantime," his father added brusquely, "here is 5,000 lire for the wire and—and the other things—you said you needed."

CHAPTER FOUR

TEST ON A LONDON ROOFTOP

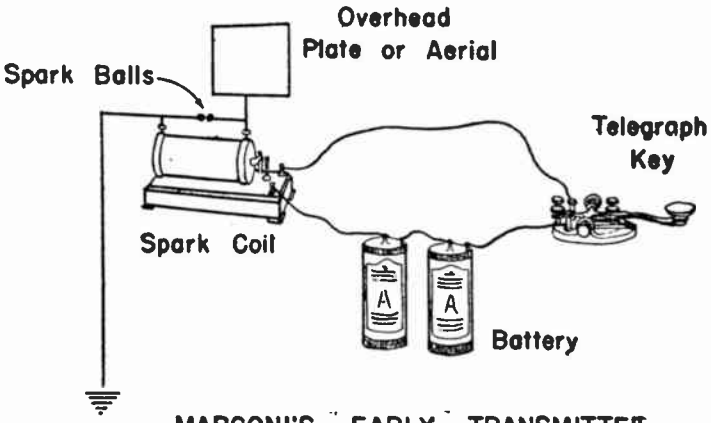
FIVE THOUSAND lire was about $1,000. It bought a lot of equipment. And with his increased store of wires and bits of metal Marconi went to work with renewed energy.

Distance was what he wanted. And distance he was determined to get. His apparatus worked very well for 200 feet, and it seemed to him a simple deduction that an improved form of the same apparatus would work for a greater distance.

Things always seemed simple and obvious to Marconi, and that characteristic was later to make him appear strange and incomprehensible to many men. What they labored and

studied over was so often made perfectly clear to him in a flash of intuitive understanding. And therefore he, sometimes, could not understand other men. He was still, for example, puzzling over the fact that none of the great scientists had tried to apply the principle of the Hertzian waves to practical communication. Surely any day now he would read that what he was trying to accomplish had already been done by one of the wise men in their laboratories. Surely they must have recognized this possibility, if it had occurred to him—the merest amateur of electricity? But the weeks went by and no one else announced the invention of a system of communication without wires. And Marconi went on working.

To improve the apparatus—that was his job. First he decided that if the small metal plates attached to the spark balls would radiate weak electric waves, larger plates would radiate stronger waves. So he tried it and it worked. The waves were stronger and therefore they carried farther.



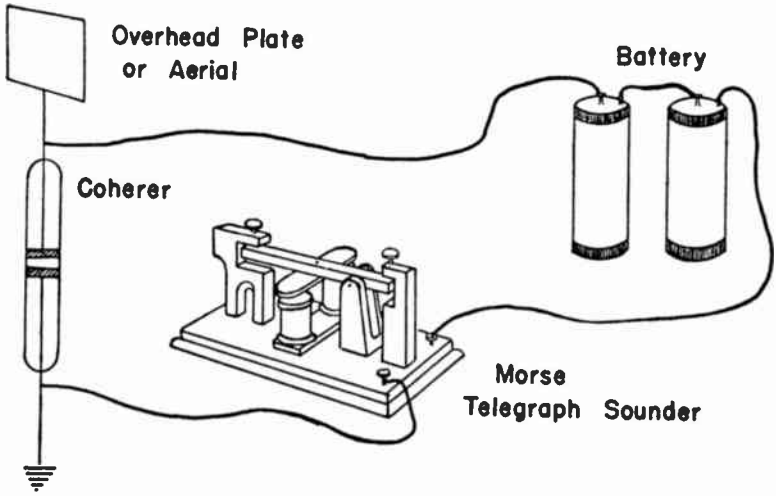
MARCONI'S EARLY TRANSMITTER

Good. Now what else could he do? He conceived the idea of fastening one plate to the top of a tall pole stuck in

the garden, and the other he buried in the ground. And that helped too. It didn't occur to Marconi that he had done anything very remarkable that day—he was just following his usual system of trying the obvious next step. But that next step happened to be an important advance in wireless—the aerial and the ground had been invented.

His signal was now immeasurably strengthened. Carefully he made his pole higher and higher and higher. And each additional inch increased the distance at which his coherer would respond to the sparks.

Perhaps the system that had worked so well for one end of the apparatus would work as well for the other. Marconi connected one end of the glass tube of his coherer to the raised plate, and the other end to the buried plate. And his reception improved again.



MARCONI'S EARLY RECEIVER

Now he would try it out on a really great distance. He would see if he could transmit to the far end of his father's garden—1700 meters away from the attic window. When

his arrangements were complete he asked Alfonso to stand beside the coherer with a white flag in his hand; if the coherer clicked Alfonso was to wave.

From the attic window where he himself sat he could look across the garden as it sloped down away from the house and then rose again to the little hilltop where Alfonso stood, a little more than a mile away. Alfonso was a tiny black speck, and the flag in his hand an even tinier white one. Would the waves really find their way to the target of that distant plate, glinting faintly in the sun on top of its pole? Well, there was only one way to find out.

He reached out his hand to the key. Once, twice, three times it clicked. And almost simultaneously the speck that was Alfonso began to bounce up and down in the air, and the smaller white speck moved violently above it. The coherer had clicked too.

From inside the house Giuseppi Marconi also saw those distant signals of success. "He's getting to be as bad as Guglielmo. Just look at him," he said brusquely to his wife, perhaps because he did not want to admit that he too was a little excited.

Very well. The 1700 meters were all very fine. And perhaps another man would immediately have announced to the world that he had performed a miracle. But Marconi only told himself that crossing a clear meadow was after all not much of a success. To be commercially practical—and this was the ideal he always held before himself—wireless would have to hurdle obstructions. To climb the top of a tiny hill was not enough. It would have to cross the hill. Eventually it would have to cross mountains.

By this time Alfonso, in spite of the nine years difference between the two boys, served as his younger brother's will-

ing assistant. The peasants on the estate, too, lent a hand. They had always been indulgent toward the young Guglielmo, and perhaps this was indulgence too. But Marconi was not a child any more; and certainly none of them helped him out of interest in or understanding of his strange ideas. No. Marconi even as a young man was able to win loyal supporters. Many years later Edison was to say of him, "He looks like an easy man to work with." And he was, from the very beginning.

So, with the aid of Alfonso and a few of the men, he moved the coherer over the crest of the hill into the valley beyond. Now Alfonso at his station would be completely invisible from the attic window. Good. That was as it should be. But the white flag wouldn't work as a signal this time. They needed— A gun, that was it.

And then once more Marconi sat alone and tapped his key three times. And an instant later the sharp report from over the hill told him that the sparks had done their job. Even hills could not stop them.

Giuseppi and his wife were called again to witness. The three clicks—and the noise of the gun shot into the air.

This time the shrewd Giuseppi himself recommended the next step. He no longer needed convincing. He believed. And therefore anyone would believe. Marconi must write to the Italian government. This was going to be a big thing; it would need government aid and support. And, under the circumstances, the government would surely be glad to offer it.

So the letter was written. And before very long the answer came. The government did not belittle Marconi's invention; they thought his work was interesting. But to finance it out of government funds? That was something

else. The letter closed with a suggestion that perhaps, since it looked as though the invention might be most usefully applied to ship-to-shore communications, Marconi might take his designs and apparatus to England, owner of very many ships. Italy, the letter implied, could get along without wireless telegraphy.

"I will write to my family and friends in England immediately," the Signora Marconi said the moment she had finished reading the polite last words. "You and I can leave for London as soon as the answers come."

Yes. They could leave for London. It was the only thing to do. Marconi thanked his mother and went back to work.

Italy wasn't interested—his own country, which he loved with the patriotic fervor that claimed so many of its young men in that period, shortly after Victor Emmanuel had unified the kingdom. Italy was, her youth believed, coming into her own; they were proud of her; they wanted to be a part of her development. Marconi's appeal for aid had, in his own eyes, been a gesture of homage—an offering of all he had accomplished—to the country he loved. The offer had been rejected.

But emotion was not something you displayed. It was something you kept to yourself. So he went to work again, while downstairs his mother wrote fervently and hastily.

This time there was no need for members of the family to avoid one another's eyes when the answers came, to pretend that disinterest on the part of the world did not matter. This time the news was good. Almost before he knew it Marconi and his mother were ready to leave. England was far away; and, his childhood visit there forgotten, it seemed perhaps a strange and unfriendly land. He would miss the Villa Grifone, and the gardens that seemed almost a part of his

experiments. And gay generous Alfonso, and his father's sharp comments. Nevertheless, the obvious next stop was England and the formidable task of convincing the hard-headed Englishman that the wireless was a practical invention.

Colonel Jameson Davis, their cousin, had found a house for them by the time they arrived in February 1896. It faced on a square, as Marconi's birthplace had done, but even that did not make it seem like home. For an English square was somehow very English, and busy sprawling London made Pontecchio seem very tiny and very remote. And too, it occurred to Marconi that an experiment over which a fond family and admiring peasants had marveled might, here in the greatest metropolis of the world, be lost—or, worse than that, laughed at. The people he wanted to see were important people; but would important people bother with a 22-year-old youngster who claimed that he could signal through empty air?

Well, first he must have something ready to show them should they prove willing to look. While his mother was still settling them comfortably he was already at work setting up and repairing his apparatus once more. He refused to interpret as a bad omen the fact that the customs authorities had smashed his machinery because they didn't understand it, and it looked "dangerous." He would remember instead that Colonel Davis, himself an engineer, was interested. Surely that was a good sign. When things were in working order the Colonel even brought others to look at his young relative's contraption.

Finally an appointment was obtained with Sir William Preece, chief engineer of the British Post Office. Armed with

a letter of introduction, Marconi presented himself to the genial 60-year-old Welshman, who had been working in the field of telegraphy since before Marconi's birth.

Silently he waited while the letter was read.

"So," Sir William said finally, "you have invented a system for transmitting Morse code through the air without the use of wires."

Marconi said nothing.

"You know," the older man continued, with a slight smile, "I myself have done some experimenting in that direction." He looked at Marconi closely, perhaps wondering to himself just how old this fellow was. He looked very young, and yet there was something about him—a quietness, a purposefulness— "Tell me something about it," he said.

"Well, you see, sir, I utilize the Righi spark transmitter to generate waves and the Branly coherer to detect them. I have improved the coherer and made it much more sensitive to the presence of electric waves."

"I see. You know, Sir Oliver Lodge, two years ago, performed an experiment in which he sent waves 180 feet to be detected by a coherer."

Marconi smiled but his voice was respectful. "I have operated a telegraph ticker by means of these waves over a distance of almost two miles, sir."

There was a brief pause.

"With the apparatus you speak of?"

"Yes, sir. I have just obtained a patent for it."

There was another small silence. So he had obtained a patent, had he? He was not, then, just another dream-crazed young man with a wild idea. He had his feet on the ground. He knew what he was doing. He had waited until his appa-

ratus worked—if it did work, of course—over a distance of almost two miles before bringing it to the attention of the world.

"I would like to see this apparatus, Mr. Marconi," Preece said.

"It would be an honor to show it to you, sir."

It was more than an honor, Marconi found. It was an inspiring experience. To Preece one did not have to explain things by means of childish stories of ripples in a pond. Preece's own background in the field of electro-magnetic waves was far superior to Marconi's. He grasped every detail of the simple handmade apparatus with its aerial and ground connection.

And as he studied them, Preece himself lost every doubt he might have had of this young man's astonishing achievement. His own engineering training told him that this might very well prove to be exactly the method needed for long-distance reception. Before he left he offered Marconi the use of his own laboratory, and promised to use his influence in arranging a demonstration of the wireless system for the heads of the British Postal Telegraph Department.

As easily as that, even before he had made any public demonstration, Marconi began to find himself talked about in engineering circles. When Preece gave a lecture on "Telegraphing Without Wires," in December of 1896, he described the young Italian's miracle and expressed his own complete faith in its eventual success. And he made announcement of the fact that the Postal Department was offering every possible facility to the young man, in order that he might prepare his apparatus for a test.

Marconi was working long hours, but such encouragement had given him new strength.

Then came the word from Italy: Marconi's temporary residence in England was not to be considered as excusing him from military service; he was still an Italian citizen, and military service was compulsory. There was one alternative to leaving his work and returning home: he could renounce his Italian citizenship.

It would have been an easy way out. He *couldn't* give up his work now; he might never have another similar chance to catch the attention of the very people who could make his dream a reality. And after all, Italy had not been interested in his invention; why should he sacrifice himself to serve her?

But even that cool letter had not dampened his ardor for his own country. If it were a choice of giving up wireless or giving up his citizenship, wireless would have to go. Unless—

Marconi talked to General Ferrero at the Italian Embassy in London.

"I don't want to leave now, sir," he concluded, "but if it's a case of giving up my citizenship—"

Ferrero nodded. He had been hearing about this young compatriot of his in important circles in London. If what he heard were true, Marconi could far better serve his country and himself by remaining where he was.

"Let me try to see what I can do," he said. And when Marconi had left he dispatched a letter to the Minister of the Navy in Rome. Benedetto Brin was, he knew, an understanding man.

Brin wrote back with the suggestion that perhaps the Navy might be able to assign Marconi to London as an attaché of some sort, provided, of course, Signor Marconi could give some proof of sea activities in his past. Could he?

Ferrero sent for Marconi and put the question.

"Very well, Excellency," Marconi answered, with a little

smile in his eyes. "I had a small fishing boat at Leghorn. We many times put to sea to fish, as many of my friends will be able to testify."

Ferrero smiled back at him. It wasn't much. In fact it was almost less than nothing. But he and Brin, between them, they would make it do.

In due course Marconi received appointment as naval attaché to the Italian Embassy. His duties, by a fortunate coincidence, left him plenty of time for continuing his work. And—perhaps by another coincidence—donations in the exact amount of his military service pay began to arrive regularly but anonymously in the office of a London charity.

And now the hour for the fateful test drew near. Carefully, slowly, Marconi dismantled his coils and batteries and wrapped them up. With the fragile coherer one must be particularly tender. When all was finished they were transported through the streets and then he set to work assembling them again. On the roof of the General Post Office was one transmitting and receiving apparatus; and 100 yards away, across the sooty London chimneys, was a duplicate array of machinery.

The great day arrived. Dignified officials were introduced to Marconi, one after the other, and then the entire party climbed to the roof. Marconi made a last-minute check-up of all his equipment and tried not to notice that the top-hatted dignitaries raised their eyebrows at the crudity of the little handmade articles assembled there.

There was another thing they were aware of, and Marconi sensed their awareness. That little spark gap transmitter had been invented by Hertz. And the coherer belonged to many men—Hughes, Varley, Branly and Lodge. It was improved now, of course, but the essentials were not new. Would the

important gentlemen laugh at him for trying to pretend that he had invented something, when all he had actually done was put together the inventions of other people? Or would they recognize in that crude metal can set on top of a pole an important development for which Marconi deserved full credit? Marconi knew now that the aerial and its ground comprised a valuable addition to the triumphs of electrical engineering. But would they know it?

Or suppose the apparatus refused to function at all? It had happened in the past. The air waves were treacherous things.

Suddenly Marconi pushed all these fears out of his mind. All this worrying over the outcome of the demonstration was foolish. The thing to do was to get on with it. If it worked and they liked it—well and good. If it didn't, he would find out about that soon enough.

Preece put a hand on his shoulder. "Well, Mr. Marconi," he said gently. "Ready?" Marconi nodded.

The conversations on the roof ceased. Marconi stood in front of his key and gently he pressed it. For an instant the crackle of the sparks was the only sound to be heard.

But immediately afterward it was followed by an answering signal. Breathing more easily, Marconi dispatched a telegram spelled out in Morse code, and the answer to that too came winging back over the rooftops.

The demonstration had been a success. And the gentlemen in the top hats did recognize Marconi's contribution. With the British government as a sponsor, the path in the future should be easier.

CHAPTER FIVE

ITALY CHANGES ITS MIND

By no means all the people who heard of Marconi's successful Post Office experiments were convinced of the future of this wireless telegraphy. Many insisted that the system could never be improved to the point where it would transmit messages over long distances, and they pointed out that communication over a mere few hundred yards of space would not be very useful.

That sort of criticism could easily be met by a demonstration of more spectacular dimensions, and such a demonstration was already planned. It had been decided that it would take place on the Salisbury Plain—a great flat sweep of country in the south of England that might have been designed expressly for Marconi's experiments, so convenient was it.

Another type of criticism might prove more bothersome. It was concerned with the fact that wireless telegraphy was not secret—anyone with a coherer could pick up the Morse

signals sent out, and anybody who wanted to go to the trouble could easily construct a coherer. Those who expressed this point of view did not belittle the miracle of wireless; it was, they admitted, a fantastic and wonderful thing. But as a commercial possibility? As a system to be used in the same way that the telegraph was used?

"Nonsense," they said. "Who would ever send a message that could be read by almost anyone? It would be like printing it in a newspaper. With regular telegraphy there is a decent secrecy—no one reads a message except the sender, the two operators, and the receiver. But with this Marconi system—why, anybody and everybody would know your business."

The 22-year-old inventor, preparing for the Salisbury Plain experiment, was well aware of this argument and of its potency. In fact, he was at the moment working toward what he hoped might be an answer to it.

As he sat in his room one day, waiting restlessly for some new material he had ordered, there was a knock at his door.

"Come in," he murmured, without turning from his workbench.

The door creaked open and his mother's voice spoke. "There's a man downstairs with two large copper pots," she said. "At least, they look like pots. And he says they're for you." She walked over to join him at the bench. "Aren't you satisfied with your meals here, my son? Are you going to do your own cooking—here in the workroom?"

Marconi turned to find her smiling at him. "Send them up, Mother," he answered. "Yes, I'm very well fed—thanks to you. But I'm going to try a new recipe for wireless."

"They're such big pots," she murmured. "We could cook a great deal of spaghetti in them—a great deal."

"Imagine sending long strands of spaghetti through the air," he teased her.

"It would be very convenient," she said over her shoulder as she went toward the door. "I could have it flown up here from the kitchen, instead of having to climb these stairs after you every mealtime."

The copper bowls arrived, looking like big searchlight reflectors. Marconi paused to admire them for a moment and then he set to work. He carried one of them to the table at the far end of the room where his spark gap transmitter stood, and fastened it behind the spark gap so that its polished inner surface was close to the spark balls. The other bowl was similarly secured behind the coherer, or receiving equipment, at the opposite end of the room.

Then he carefully turned the pieces of apparatus so that the bowls faced each other exactly.

If his theory was correct—that wireless waves could be aimed, as light waves were—he should be able to direct his waves accurately across the room into the reflector behind the coherer, where they would be concentrated and directed immediately at the filing-filled tube. If he could do that he would accomplish two things at once: he would get more power, because the waves would not be dissipated in every direction, but concentrated toward the coherer; and he would also achieve a measure of privacy, because only the coherer toward which the waves were aimed would be able to pick up the signals.

There. Now everything was ready. He pressed the telegraph key, the spark leaped, and across the room the coherer clicked. Good. That was the first step: he was sure now that the copper bowls had not interfered with the transmission.

But in itself that was no proof of anything more. Across

a room like this any kind of wave, weak or strong, would have reached the coherer. The important thing to discover was whether the coherer would click even if the bowl backing the spark transmitter were so turned that the spark was directed away from the receiver.

He turned the transmitting apparatus entirely around, so that it faced in the opposite direction. Again he pressed the key. And this time the coherer remained silent.

Triumphant, but still unwilling to accept this as final proof, he turned the transmitter again so that it was at right angles to the receiver. Again the spark crackled and again the coherer was silent. Back and forth he twisted the transmitting reflector, trying it at every angle, and finally he stopped and sat down with a sigh.

The reflectors were effective, and he had discovered that he could keep the waves in a beam about 30 degrees wide. He could not narrow them further than that, but even so he had managed to achieve a degree of the privacy his critics demanded. The new theory was certainly worth trying on the Salisbury Plain.

He explained his idea to Preece as he worked over his equipment being set up for the forthcoming demonstration.

"But can you focus your waves with such small reflectors?" Preece asked curiously. "You were using waves more than 200 feet long in your last experiment, weren't you? And surely a reflector would have to be larger than your wave length."

"These are short waves I'm using now," Marconi answered. "I can't measure them accurately, of course, but estimating from the size of the spark, the size of the spark balls and the voltage I'm using, I believe they're about two feet long."

Preece's eyes widened. "As short as that? But will they behave generally as the longer ones do?"

Marconi smiled diffidently. He wasn't sure himself. "We'll find out very soon now."

The Post Office officials arrived. But this time their top hats were put to shame by the uniforms of the Army and Navy representatives present. Wireless—if such a thing were possible—might prove very useful to the armed forces, and these men were there to see it for themselves.

The first tests reached the coherer at a distance of 100 yards. Marconi moved the receiver farther away—so that the distance between it and the transmitter was more than a mile. Again the waves leaped across and the message was clicked off.

During the few days of the demonstration's duration the coherer was moved six miles from the transmitter, and finally nine miles away. In every case the coherer responded perfectly. And in every case, when the transmitter's reflector was turned away from the receiver, the coherer did not respond.

The Army and Navy and Post Office officials were all well satisfied. But Marconi himself was not. In wireless itself he had lost no faith. But the new short waves—they had not performed as well as he had hoped they would. For some reason he didn't understand they seemed weaker and more easily blocked by hills and by the natural curvature of the earth. He came to the unwilling conclusion that they traveled in a straight line right off into space—like the tangent of a circle—instead of hugging the earth's surface and curving with it, as the longer waves seemed to do. Short waves and reflectors were not the means to long-distance transmission.

And long waves could not be used with a reflector for the reason Preece had mentioned: it was necessary that a reflector be larger than the length of a wave; reflectors for waves 200 feet in length were obviously impractical.

But still he refused completely to abandon his hopes for the short waves. He actually filed a patent for the system he had used on Salisbury Plain—a patent which ran out before the day, many years later, when he began to work with them again, and, together with his brilliant staff engineer, C. S. Franklin, developed the short-wave beam transmission which made world-wide communication a fact.

Marconi returned to his old problem of achieving greater distance with his original long waves. He grubbed away in his workroom, trying one new idea after another.

One day, during this period, he made an acquaintance that was to be very important to him. He had climbed a roof where an aerial had been erected and, clinging precariously to his awkward perch, was endeavoring to make some necessary repairs. A casual voice hailed him from below.

"What are you doing up there?"

Marconi glanced down. Usually somewhat impatient of the questions of curious strangers, he suddenly felt impelled to make friendly if brusque answer.

"Come on up and help me if you really want to know."

The stranger stood still for a moment and then, with a grin, moved toward the building and climbed up to join the young man on the roof. To Marconi's surprise he seemed to know what an aerial was, and his hands were quick and skillful. Almost before either of them realized it, they were working together on the job.

The man said his name was Kemp—George Stevens Kemp.

He had been in the Navy, he said, but at present he was an engineer attached to the Telegraph Department of the Post Office.

"The Postal Telegraph Department?"

"That's right."

"Why, then you know—"

Kemp's friendly face grinned. "That's right."

And before very long it happened that Kemp was transferred from his current job to serve as Marconi's assistant during his work for the Post Office experiments. He was Marconi's assistant to the end of his life, and his round face with its luxuriant walrus mustaches was to become almost as well known to the public as Marconi's own slender figure and serious eyes.

In the spring of 1897, the following year, in response to the continued widespread feeling that wireless would prove most useful over water, Marconi moved his equipment to the Bristol Channel. That deep inlet on the southwest coast would offer, he thought, just the conditions he sought.

At Lavernock Point he set up a receiving station, and on the channel island of Flatholm, three and a half miles away, the transmitter was erected. On May 11th everything was in readiness for a test. The Flatholm station sent its signal—and it was not received. All day long repeated attempts were made, while the apparatus was constantly checked for whatever minute mistake might be causing the failure.

Wearily, late at night, Marconi and his assistants went to bed. And bright and early the next morning they were up to try again. Perhaps they had been too tired the day before to catch their error, but now they were fresh. It would be a simple matter now to go over everything carefully, discover what was wrong, and conclude the test successfully.

But May 12th was a grim repetition of the day before. Not a signal came through. This was the first test of wireless over water—and it had failed.

With infinite care Marconi went over everything again. The receiving apparatus on the cliff at Lavernock Point, 60 feet above sea level, seemed to be in perfect order. His cylindrical zinc aerial, six feet long and three feet in diameter, set atop a 90-foot pole—that too was as perfect as they knew how to make it. The ground wire, running 60 feet down the cliff into the sea, had not been broken or worn away. A similar check-up at the sending station was as unproductive. There was nothing wrong anywhere—but the coherer remained silent as the grave.

As evening came on the observers present wandered away, glancing significantly at one another. Was this the miraculous invention they had come to see?

"The fellow claims he transmitted nine miles on Salisbury Plain," one of them murmured. "Perhaps he—exaggerated a trifle?"

"But I know he did," one of the others said stanchly, in the midst of the laughter that greeted that remark. "I was there. I heard—"

"Perhaps you exaggerate a trifle yourself," the sceptic retorted. And the laughter sounded again.

May the 13th came, and the regulation tests were made in the morning with little hope of success. They too were failures.

Marconi thought of the Villa Grifone, of how his father's face would look if he returned home.

But he wouldn't. He couldn't. He *knew* wireless worked. Surely he would not be discredited because of one unsatisfactory test. But why was it unsatisfactory?—that was the

point. If he only knew, he could do something about it; or he could say, "Very well. But under slightly different conditions all would be well"—and then set out to show that that was so. *If* he knew what was wrong. But he didn't.

And then someone said casually, "Perhaps if we moved the coherer down to sea level—"

It was a forlorn hope, but anything was better than the painful inactivity that had settled over all of them when the last check had been concluded.

Carefully the coherer was transported to the bottom of the cliff. Now the aerial was the height of the cliff plus the height of the pole—a total of 150 feet.

In spite of the weariness and the strain, Marconi's will kept his hand steady. They were ready to try once more.

And this time the signals came through, their sureness and strength mocking the unbelievers. The steady succession of dots and dashes sounded almost like a little chuckle. "So? You didn't think wireless was a fact? Well, well. Now you know better."

The past few days had been a nightmare, but now young Marconi was awake again and he could put them out of his mind.

The added length of the aerial had made all the difference, perhaps not only to this one test, but to the entire future of wireless. For if that important test had failed, the gradually strengthening support that had been rallying around Marconi's cause might have melted away like snow in the sun.

Professor Adolphus Slaby, the German scientist who had been experimenting with wireless in his native country, was one of the observers on that momentous day. His own words describe very well the feelings of those present when the signals finally came through:

> It will be for me an ineffaceable recollection. Five of us stood around the apparatus in a wooden shed as a shelter from the gale, with eyes and ears directed towards the instruments with an attention that was almost painful, and waited for the hoisting of a flag, which was the signal that all was ready. Instantaneously we heard the first "tic-tac, tic-tac," and saw the Morse instrument print the signals that came to us silently and invisibly from the island rock, whose contour was scarcely visible to the naked eye—came to us dancing on that unknown and mysterious agent, ether.

The transmitter was moved to Brean Down, nine miles away on the far side of the channel, and still the signals came through clearly.

The Post Office demonstrations and those on Salisbury Plain had created a good deal of interest among engineering and scientific circles, but for some reason the Bristol Channel success caught at the fancy of the general public as well —and for the first time. Not everyone was enthusiastic about Marconi, but fashionable London claimed him for its own, and he was the guest whom hostesses clamored to obtain for their parties.

The ladies eyed him over their fans and talked about him in discreet whispers. "He's *quite* handsome, don't you think —in an austere sort of way." "Oh, but I don't think he's austere at all. He's probably just shy. After all, he's terribly young—only 23, they say."

Marconi wasn't shy, but he thought parties were a waste of time. He didn't mind repeating an experiment a hundred times, for his own satisfaction or for interested students of wireless; but to have to spend an afternoon balancing a tea cup in one hand and a plate of ices in the other, making polite conversation with women who smiled archly and said "And now, Mr. Marconi, I want you to tell me *all* about wireless"

—*that* was simply throwing time away. He must often have regretted the charming manners and the command of English which his mother had been so careful to give him; they were, now, just two more reasons why hostesses sought his presence.

But life offered a splendid compensation for the mute suffering Marconi underwent for a while as the newest social lion of London. Sir William Preece, convinced now of the ultimate success of Marconi's wireless, abandoned his own experiments in the field, and devoted much of his time to spreading the story of the young Italian's discovery. He was going to "sell" wireless to England. He was a stalwart champion, and England could not remain for long unaware of a man about whom Preece talked so frequently and so enthusiastically.

But to be aware of him was not enough. All England was not so openhearted toward this new inventor as he was himself, Preece discovered. For one thing, people pointed out, Marconi had really added very little to the already known work of other men; you might almost say he hadn't actually invented anything at all. And furthermore he was a foreigner—and a very young foreigner at that; why should they grow excited about him when men of their own country—Sir Oliver Lodge and Preece himself, for example—had conducted experiments with systems of wireless telegraphy. They preferred to give their allegiance to English inventors. Why, they could remember quite clearly that in 1895, when the underwater cable had broken down between the Isle of Mull and the mainland, Preece had sent messages without wires for a distance of two miles. What was wrong with his system?

Preece kept his temper and answered their questions

calmly. There were a lot of things wrong with his system, as he very well knew. He hadn't used Hertzian waves at all. He had used the principle of induction in a system that required radiating wires—similar to aerials—equal in length to the distance across which the signals were to be flashed. Thus, to transmit across the two-mile channel between the Isle of Mull and the mainland, he had had to stretch two miles of wire on the island and another two miles, roughly parallel to the first, on the shore. In his own mind it was evident that no such system would ever suffice for any long-distance communication, and it would obviously be of no use in ship-to-shore telegraphy. For if a ship were so much as ten miles off shore, he reasoned, where on board her could one stretch ten miles of wire? Why, the Preece system couldn't even be utilized by a ship one mile at sea.

But the general public was not sufficiently well educated in technical matters to understand the situation readily. Preece had sent messages without wires. And he was English. Why then should they care about Marconi?

In June 1897, Preece lectured at the Royal Institution on "Signalling through space without wires." Patiently he went over all the older methods—including his own—pointing out their defects. And then he demonstrated Marconi's apparatus, explained its features, and described the experiments with it he had himself witnessed. In an obvious attempt to prove the superiority of Marconi's system over his own he said:

> The peculiarity of Mr. Marconi's system is that, apart from the ordinary connecting wires of the apparatus, conductors of very moderate length only are needed . . .

and he directed his conclusion to those critics who com-

plained that the young Italian had added nothing to what was already known:

> He has not discovered any new rays, his recorder is based on Branly's coherer. Columbus did not invent the egg, but he showed how to make it stand on its end, and Marconi has produced from known means a new electric eye, more delicate than any known instrument, and a new system of telegraphy that will reach places hitherto inaccessible.

His campaign had been by no means harmed by the publication, in March, of an interview with Marconi appearing in the popular American *McClure's Magazine*. If the young man deserved the attention of a famous editor across the ocean, Englishmen reasoned, perhaps they themselves ought not to slight his accomplishments so carelessly.

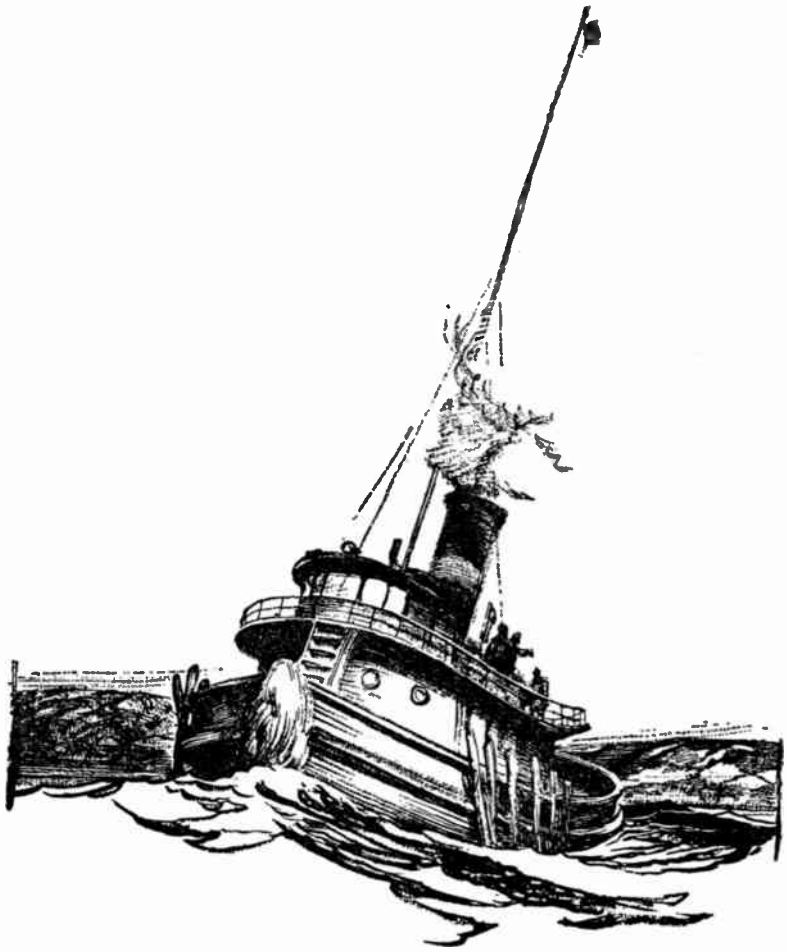
Marconi described his work for the *McClure* reporter in simple terms understandable to a layman, and also apparently impressed him with his own personality. For the reporter wrote:

> He is a tall, slender young man, who looks at least thirty, and has a calm, serious manner and a grave precision of speech, which further give the idea of many more years than are his. He is completely modest, makes no claims whatever as a scientist, and simply says that he has observed certain facts and invented instruments to meet them. Both the facts and the instruments are new, and the attention they are at present exciting is extraordinary.

Fortunately for Marconi, nothing arouses public interest so rapidly as a printed statement saying that public interest has already been aroused.

And then suddenly something occurred which drove all other thoughts out of the inventor's head: he received an invitation from the Italian government to go to Spezia and

Rome to conduct experiments there. Evidently Italy was beginning to regret its earlier decision in regard to this young man, and there may have been anxious gentlemen who feared that their new cordiality would come too late. But they were reassured. Marconi harbored no grudge. He was only too anxious to return home and to put his experiments to work for Italy. The fact that the invitation included the offer of the use of warships for his demonstrations was an additional, but by no means a decisive, favor. Marconi was eager to test his apparatus on moving vessels, but in any case he would have gone.



CHAPTER SIX

MARCONI, LTD.

ONCE MORE Marconi was preparing to disturb the placid air of Italy with his electro-magnetic waves. But this time he would be working in a new way: he intended to observe the behavior of his waves from a moving receiving set.

The transmitter was installed according to schedule shortly after his arrival in July. It was located near the arsenal of St. Bartholomew on the inner shore of the Gulf of Spezia, formed by a rocky peninsula extending southward into the Mediterranean between Genoa and Leghorn on the western coast.

It consisted of the usual spark gap, fed from a high-voltage induction coil; the current, supplied by batteries, yielded a spark ten inches long. The aerial was a vertical wire 78 feet in height, ending in a zinc plate. The receiving apparatus, installed on a tug anchored near by, was connected to an aerial 48 feet high, grounded in the water of the bay.

When all was in readiness Marconi set out on the tug, and the shore station began to flash its signals. Slowly the heavy boat moved farther from the shore, and still the signals came through, until reception was achieved at a distance of two and a half miles. To Marconi's chagrin, however, static—or atmospherics, as it was then called—was present to an irritating degree. Feeling that stronger signals would help to overcome it, he had the aerial of the transmitter raised, on July 15th, to 90 feet. This time thunder clouds played tricks with the transmission, but later in the day the weather cleared sufficiently for the signals to come through, and the tugboat received them successfully at a distance of three and a half miles. And then the boat rounded the headland of the promontory and the signals ceased altogether.

The next day Marconi kept the tug within sight of the transmitter and the signals continued to arrive successfully until the boat was eight miles away.

Thereafter the receiver was transferred from the tug to a warship, the *San Martino,* and the aerial at that end was increased to 90 feet; the transmitter's aerial was also raised,

to a height of 111 feet. With these changes in his equipment Marconi succeeded in receiving messages up to 11½ miles from shore—the greatest distance he had yet managed—but only if he did not permit his traveling receiver to round the headland.

The new distance was an achievement, but the experiment had created its own problems. For one thing, Marconi had discovered that when the ship's rigging came between the receiver's aerial and the shore transmitter, the signals were appreciably weakened. This difficulty was not one he had been entirely unprepared for, because Hertz had written of his inability to send electric waves through a metal screen. But, in spite of his foreknowledge, he recognized the seriousness of the implications for the future; if wireless was to prove successful for ship-to-shore communication, the aerials on shipboard would have to extend high enough above all other ship's wires to overcome this screening effect.

More serious in its implications was the complete blanketing of all reception when the headland lay between the transmitter and the receiver. Of what use would his waves ever be if they proved unable to cross hills and mountains? But this problem, far from discouraging Marconi, only served to spur him on. He tabulated carefully all the results of his recent days at sea, and found that there was a definite connection between the height of the transmitting aerial and the distance over which messages could be received. He wrote:

> I find that with parity of other conditions, vertical wires 20 feet in length are sufficient for communicating one mile, 40 feet four miles, 80 feet sixteen miles, and so on . . . That is, if the height of the wire is doubled, the possible distance becomes quadrupled.

Much that was later clear to scientists was not understood at that time. An increase in the size of the aerial automatically lengthens the wave of the transmitter, but it was only later that it was known that longer waves are less affected by such obstacles as hills and mountains. Marconi's ignorance of that characteristic of long waves was unimportant, since he did realize that higher aerials yielded greater distances. However, he also realized that there was a definite limit, from a practical point of view, to the height an aerial might be raised. Therefore, he reasoned, some other method must be devised to make the waves travel farther and to make them independent of obstacles.

Marconi decided that a possible solution lay in more powerful transmitters, with sparks huge enough to create waves that could travel a long distance before they were finally lost.

Then, his work at Spezia completed, he packed up his equipment and traveled to Rome, where the king and queen had expressed a desire to see wireless demonstrated. That particular exhibition must have been the most thrilling of Marconi's life. Royalty was always to have a very special glamor for him; long after most people had ceased taking titles very seriously, Marconi continued to regard their bearers—even the lesser ones—as wonderful beings, set far above ordinary mortals. But this particular occasion was more than merely his first meeting, face to face, with a king and queen; it was Italy's accolade for a very young and very patriotic subject. And any faint hurt Marconi might have retained over that brusque letter sent to the Villa Grifone was wiped out forever when he received the invitation: his own sovereigns would be pleased to see him and watch him demonstrate what they were kind enough to regard as a most interesting invention.

Probably, that day, Marconi's hands were unsteady. And undoubtedly the London ladies who had thought him shy would have had their verdict amply verified. But he need not have worried. King Humbert smiled through his bristling white walrus mustache, and asked kindly and interested questions. Queen Margharita's gentle round face puckered with fascinated concentration as she watched the blue spark leap and listened to the little clicks that spelled out words.

Now nothing, young Guglielmo thought fervently, could ever discourage him again. His king and queen approved.

After that memorable day there were demonstrations at the Chamber of Deputies, where stout florid gentlemen added their words of praise to that of their rulers. Marconi and wireless had been gloriously justified.

In the meantime, back in England, Preece had been tirelessly carrying on his self-appointed job. He made speeches, he exhibited Marconi's apparatus, and—most important of all for the future of wireless—he finally managed to convince a group of hard-headed businessmen that wireless was a sound investment. He did not attempt to cajole them with pictures of immediate wealth; he told them frankly that for years to come they might do nothing but pour money *into* experiments; but eventual success, he insisted, was certain. And finally—for Preece was a man they could trust, and the demonstrations *were* convincing—he had his way.

Thus, upon Marconi's return, he found the ground all prepared for the formation of the Wireless Telegraph and Signal Company, Ltd.—a name changed in 1900 to Marconi's Wireless Telegraph Company, Ltd. Colonel Jameson Davis, the Signora Marconi's cousin, had continued to be interested in his young relative's invention, and he was actively en-

gaged in the new enterprise; he held the position of managing director for the company's first two years. Alfonso Marconi was also one of the officers.

Just eighteen months ago Marconi had said goodby to his father and his brothers in Pontecchio, and set out for a country which he half expected would ignore him entirely. Now he found himself signing papers in regard to a corporation capitalized at £100,000. That spectacular amount was large enough to obtain all the patent rights which Marconi had taken out; but the rights in Italy and her dependencies he refused to sell.

"But why, Mr. Marconi? Don't you understand that—?" Men twice and three times his age looked at him with mingled respect and exasperation. Of course, one didn't expect an inventor to be practical, but after all—

"I'm sorry, gentlemen. I prefer to keep Italy independent of any foreign nation."

Those were his final words, and no amount of persuasion had any effect. The gentlemen shrugged their shoulders and gave up. And Marconi smiled to himself, triumphant at the thought that he had fittingly expressed his loyalty to the country of his birth, and somewhat repaid the kindness of his king and queen. Now, even if there should ever be a war, Italy would be protected in the matter of wireless apparatus and patent rights.

Marconi himself received half the capital stock in the new company and £15,000 in cash. Overnight he was an important financier, whether he wished to be one or not—although there is little doubt that he enjoyed some aspects of his new role as much as he disliked the additional social life that was its inevitable accompaniment. He was happiest in his laboratory, and so he continued to be for the rest of his life; but

he had known, even on that day in the Biellese mountains, that he was working toward an important commercial development, and he welcomed this tangible sign of his success.

The chief purpose of the company was to be the installation of wireless on lightships and at lighthouses along the English coast. That was written down on paper in proper legal language. And it must have been a satisfying expression of the investors' faith in the young man instantly heralded by the New York *World* as "the boy wizard."

"Wizard indeed," Giuseppi Marconi muttered to himself, back home in the Villa Grifone. He looked again at the figure. Yes, it did say £100,000. What was it he had told Guglielmo not so very long ago? "If you were more practical, like me—" —something like that. He folded the letter up hastily, and turned his head to avoid catching sight of himself in the mirror on the wall. Giuseppi didn't relish the thought of seeing himself blush.

And now, reinforced by a company which would back his experiments, and by a comfortable private income, Marconi once more tackled his problem. Salisbury Plain was again chosen as the site of the transmitter, and the apparatus was set up under the brooding guardianship of Stonehenge—that formation of enormous, upright rocks, whose origin has puzzled men for centuries. Now visitors to the Plain could wonder about the new enigma when they wearied of the old one, could stand staring at a slender aerial that a young man had planted in the ground, when they tired of gazing at the rocks that had been planted there by heaven alone knew what ancient race. To the farmers shepherding their sheep, and to the picknickers from the city, the new mystery was just as fascinating as the old one.

But the receiver, this time, was established at a daring distance, in the famous resort town of Bath, 34 miles away. A reference to this occasion in a speech made by the chairman of the new company points out a factor that was as important for the future as was the remoteness of Bath; he says that a post office official "went to Bath and by himself rigged up a station." Marconi was not forgetting his early determination to keep wireless simple and easy to operate.

To the satisfaction of the inventor and his fellow stockholders, the new tests were a great success. Thirty-four miles was no small span, and the bridging of it seemed sufficient excuse to spend more money on the next experiment. That was fortunate, because Marconi had set his heart on a permanent station. He felt that the movable equipment he was then working with was no longer good enough. His delicate coherer ought, he thought, to be adjusted and then let alone; moving it continually, readjusting it for every test, was scarcely the fairest method for proving its capabilities. And, too, he wanted to be able to get enough current to generate the bigger sparks he knew he needed.

A good deal of time was spent choosing the site for the new station. The Isle of Wight, in the English Channel, was finally decided upon, and Marconi and his staff set up their headquarters and their apparatus in the Needles Hotel, on the westernmost tip. Alum Bay, with its famous colored cliffs, was spread out below them, and when their eyes were tired from the strain of working over the instruments, they could enjoy its beauties. One of the guide books of the period described the colors of the cliffs as "deep purplish-red, dusky blue, bright ochreous-yellow, grey nearly approaching to white, and absolute black"—variety enough for men exhausted by the drabbest workroom.

The Alum Bay station, as it was always known, was equipped with a 10-inch spark coil and an aerial 120 feet high. Installation took place without serious difficulty, and first contact was established with a receiver set up on a small steamer that cruised in the neighborhood within a radius of about 18 miles. Reception was continuous and good. Messages were sent and received with perfect accuracy at all hours and regardless of the position of the vessel.

Satisfied with his first permanent station, Marconi decided he would erect another. The site he chose for the second was Bournemouth, on the channel coast about 14 miles from Alum Bay, but the location was later changed to Poole, a further four miles distant. Poole had once been a haven for smugglers, who found its wide shallow harbor of linked lagoons favorable for their stealthy arrivals and departures, and the heath stretching far inland from the water a comfortable place to hide in when hiding seemed the wisest course.

When the two stations were both in operation things settled down to a calmer pace. There was constant communication between the two, and it was possible to make minute improvements, one at a time, and judge their value.

While that work went on, several of Marconi's assistants were making some important demonstrations in London. At the House of Commons they put on a wireless show for England's legislators, startling the more staid of the gentlemen by setting to work with such speed that they were operating their miniature station within an hour after the arrival of the apparatus in the House.

Exhibitions were also constantly held at the offices of the new company. One of them was witnessed by a director of the Donald Currie line of steamers, and he seemed particu-

larly impressed—to the delight of the officers, who realized the importance of his influence. Over and over again they explained to him how wireless was operated, and the sort of work it could do if given a chance.

Finally, with a puzzled frown, he turned to them. "Do you mean to say," he demanded, "that if one of my ships were passing Alum Bay on its way to port, Mr. Marconi could send word of that fact to shore?"

"But of course," one of the officers answered hastily. "That is exactly what we mean. The message could be wirelessed from Alum Bay to Bournemouth, and then telegraphed or telephoned straight to you here in London. The whole thing would be a matter of minutes."

"I can't believe it. I simply can't believe it." He stood silent for a moment and then said "Look here. The *Carisbrooke Castle* is on its maiden voyage. Naturally we haven't a very good idea of what speed it will make on its first trip. And—well, frankly, we're pretty anxious to have word of it. Do you think Mr. Marconi would be able to let us know when it passes Alum Bay?"

"We'll inform him immediately to keep watch for it and send you word the minute it comes in sight."

The directors and officers were a trifle anxious themselves; it was obviously important that this little trick be executed without a hitch. And so it was. Marconi, to whom the message seemed simplicity itself, flashed the word to Bournemouth as soon as the *Carisbrooke Castle* had been sighted, and Bournemouth telegraphed the shipping company.

"You were right! You were right! And it was a matter of minutes! Why, it's a miracle!" The Currie director called the Wireless Company's office as soon as the message reached him.

The company's officials breathed a sigh of relief, assured him that it was no more than the wireless could do at any time, and congratulated each other. And, out at Alum Bay, Marconi shook his head.

"Such a simple little thing," he murmured to Kemp. "We've sent messages lots farther than that. But just because it was *his* ship, and *he* wanted to know about it—Well, I suppose you can never guess what's going to impress people."

But he smiled when he said it, and Kemp smiled back at him. For the truth of the matter was that Marconi always had an uncanny knowledge of just what would impress people, and he utilized it with a deft showmanship that consistently aided the commercial progress of wireless.

CHAPTER SEVEN

WIRELESS REPORTS A YACHT RACE

UNTIL JUNE 3RD, 1898, the Wireless Telegraph and Signal Company, Ltd., did not make a single penny, but that day marked a turn in its affairs. It was an insignificant turn, judging by the amount involved—only a little over a dollar, it was—but it was important in another respect.

Marconi was visited on that day, at the Alum Bay station, by Lord William Thomson Kelvin, the famous British

mathematician and physicist, his wife, Lady Kelvin, and Lord Hallam Tennyson, son of England's great poet. He demonstrated his apparatus for them and answered Lord Kelvin's interested questions. And when Lord Kelvin said it would give him pleasure to send messages to several of his friends by wireless, Marconi hastened to assure him that he would be glad to transmit them.

"But I want to pay, you know," the distinguished guest added.

Marconi smiled at the joke and settled down to his transmitter. But Lord Kelvin put a detaining hand on his arm.

"No, I mean it," he insisted. "One shilling per message—the regular rate of telegraphy. I know a few shillings won't purchase much new equipment, but they might help to call attention to the fact that wireless is available to the public as a commercial medium. Don't you think so?" His eyes twinkled.

"He's right," Lord Tennyson nodded. "You know he is, Marconi."

Yes, of course he knew it. Marconi hesitated only an instant and then he smiled. Lord Kelvin, an inventor himself, was a person with whom it was unnecessary to skirt delicately the importance of publicity.

"Thank you. I do." And then he added, with a mock-subservient air, "That will be one shilling each, sir. How many messages did you wish to send?"

The three visitors laughed, and put their heads together over the writing. Finally they evolved communications to be forwarded to Kelvin's chief assistant in the physical laboratory of the University of Glasgow, to Sir George Stokes at Cambridge, to Lord John Rayleigh, another English physicist, and to Preece in London.

The message to Cambridge read: "This is sent commercially paid at Alum Bay for transmission through ether 1 shilling to Bournemouth and thence by postal telegraph 15 pence to Cambridge.—Kelvin."

"Think I'll send one to my nephew at Eton," Lord Tennyson said suddenly. "Might give him a bit of excitement, you know—and the boys there will be old enough to send wireless messages themselves pretty soon."

"Sending you message by Marconi's ether telegraph, Alum Bay to Bournemouth, paid commercially, thence by wire; very sorry not to hear you speak your Thackeray tomorrow.—Tennyson," he wrote, and Marconi tapped that out too on his transmitter.

When the visitors had gone the staff at Alum Bay smiled at each other. Five shillings was very little, but they knew they had done a good day's business.

And the very next afternoon another fortunate event occurred. Their visitors included the Italian Ambassador to England, and when he heard of the previous day's messages he decided to send one himself, to an aide-de-camp of King Humbert, in Rome.

But when the operator on duty was handed the slip of paper on which the Ambassador had written he looked at it for a moment and then glanced up, puzzled.

"I'm sorry, sir," he said. "But I'm afraid I don't understand this."

"It's in Italian," the ambassador said. "Does that make it impossible to transmit? Must messages be in English?"

"Oh, no, of course not, sir. I'm sorry." The operator recovered himself quickly. "The apparatus transmits the letters one at a time—it makes no difference to the machine what words are spelled out."

A few seconds later the room was alive with the leaping blue sparks, as the operator pressed the switch up and down for the dots and dashes of the Morse code. If the receiver was also confused by the mysterious message he gave no sign. With haste and precision it was sent on over the regular telegraph wires, and within a short time it was received in Italy, exactly as it had been written.

After that Marconi could tell the critics who complained of the lack of secrecy in wireless, that messages could be sent in code or cipher, if the senders chose, and thus their privacy would be assured. The wireless could transmit a meaningless jumble of letters as well as the simplest three-letter English words. It was not, he knew, a perfect answer, but it might serve to blunt the edge of their sharp complaints.

Not long afterward the wisdom of presenting frequent demonstrations began to bear real fruit: Lloyd's, that great aggregation of marine insurors, requested a special exhibit which might, the wireless company's officials knew, lead to important commercial orders. Lloyd's wanted communication established between the town of Ballycastle on the northern coast of Ireland, and the lighthouse on Rathlin Island offshore. The lighthouse had an unobstructed view of a busy shipping lane, and could have transmitted valuable information in regard to passing ships by means of signal flags, had it not been cut off from Ballycastle's sight by a high headland. Could wireless solve the problem? Lloyd's representatives were doubtful; they feared the headland would prove to be an obstacle for the wireless waves too.

But there was no doubt in Marconi's mind. The distance involved was only a little over seven miles—the island itself was a few miles wide, and it lay only a few miles offshore—and he was certain that by this time his waves would not be

halted by the headland's height. A 100-foot pole was erected at Ballycastle to support the aerial, and an 80-foot aerial was set up at the lighthouse. To Lloyd's delight, contact was established immediately and maintained without difficulty. They were further impressed when Marconi and his assistants were able, within a brief time, to teach the lighthouse keeper how to operate the apparatus.

The demonstration had been a success, and Lloyd's had been assured that it would not be necessary to hire numerous additional employees to send and receive messages. Those two facts were enough. Negotiations began immediately for the installation of Marconi wireless transmitters and receivers in other Lloyd lighthouses—and the commercial life of the young Italian's contraption of wires and batteries was actually begun.

People began to talk of the possibility of England's seacoast being literally ringed with the aerial poles of wireless stations. Ships could be sighted several hours before they reached port and—now that wireless had a proved range of 25 miles—could be reported from rocky promontories and islands far from telegraph stations.

Marconi had ample reason to feel complacent, and to rest a while from his steady labors. But instead he kept hard at work. He had transmitted more than 30 miles, his waves had successfully overcome hills standing in their way, he had picked up wireless signals with a receiver installed in a moving ship. But there was still another feat he wanted to perform. He wanted to assure himself that he could transmit messages from a moving station. He had no idea whether the rocking and pitching of a ship afloat would disturb the waves that flew off the aerial, and he wanted to find out.

Good fortune, so consistently his aid, gave him the chance

immediately. He had been preparing his apparatus for a test when he received a communication from the famous Dublin newspaper, the *Daily Express*. At Kingstown (now called Dun Laoghaire), five miles south of Dublin, there took place each year a popular regatta; would Mr. Marconi care to install a transmitter on board a ship, establish himself within sight of the racing lane, and send messages to land on the progress of the contest?

Marconi knew perfectly well that this test would be a spectacularly public one. If he succeeded, the vast publicity would be of tremendous value; if he failed, the publicity would still be vast—and tremendously harmful. But his answer was immediate. Mr. Marconi would like to very much.

With Kemp and his other assistants he took himself off to Dublin. They chartered the tug, the *Flying Huntress*, and equipped it with transmitting apparatus and an aerial 75 feet high running up the mast. In the meantime the *Daily Express* had widely publicized the novel manner in which it expected to receive reports from the very site of the race; bulletins were to appear in its window as soon as the reports were telephoned in from the land station Marconi had set up in a room at the rear of the Kingstown harbor master's residence.

As the day of the race drew near the competing yachts arrived, each with its ardent following—the *Ailsa*, a heavy favorite; the popular *Rainbow*, the *Bona*, which had previously twice won the Queen's Cup that was the regatta prize; the *Isolde*, and the *Astrild*. The weather freshened, and the public was looking forward to an event that was to be doubly interesting this year.

But on July 20th the day was hazy. People unable to obtain space in the boats that clustered around the race course gathered hopefully at the *Daily Express* office. Was it true

that bulletins would appear there every few minutes, reporting the chances of their favorite? They had been curious about the possibility before; but now, with the haze shutting the harbor off completely, they were more than curious. It was a matter of personal interest to each one of them that the newfangled wireless should work.

Marconi, on board the *Flying Huntress,* tapped out his first message. And instantaneously, in the harbor master's house, a receiver manufactured dots and dashes on a tape. The letters were translated, even as they came over, and the moment the message was complete the reporters on hand telephoned to their newspaper offices, Kemp himself telephoned the various yacht clubs scattered along the shore—and before another few minutes had passed the anxious members, and the crowd before the newspaper office, knew exactly what had happened out in the bay so brief a time before.

10:55 THE RAINBOW, HAVING CROSSED THE LINE BEFORE THE GUN WAS FIRED, WAS RECALLED, THEREBY LOSING 3¼ MINUTES.

As excitement mounted in the town and in the crowded club rooms, the miracle of the wireless was almost forgotten —and perhaps that was the highest tribute that could have been paid to Marconi. The eager racing enthusiasts felt almost as close to the race as if it had been taking place within their sight.

The ships rounded the Rosbeg buoy and Marconi telegraphed their times as they made the turn. The *Ailsa* and the *Bona* were ahead of the others, running almost even.

THE AILSA STAYED, AND WENT AWAY ON THE PORT TACK, AS DID ALSO THE ASTRILD. AFTER GOING A SHORT DISTANCE, THE

BONA ALSO STAYED, FOLLOWING THE EXAMPLE OF THE OTHER TWO, THE RAINBOW AND THE ISOLDE STANDING IN UNDER HOWTH.

"I'm not so sure of her chances now," one watcher said to another, shaking his head over the freshly pasted-up notice as if he were actually gazing at his favorite falling behind. "I'm not so sure."

"Well, I don't know. There's plenty of time yet. There, you see!" he added, as a new report appeared. "What did I tell you?"

Wireless as such was ignored. It had become the glass through which they watched the race—a glass whose accuracy they accepted without question.

"Is it an Irish characteristic," asked a writer of the *Daily Express*, who was aboard the *Flying Huntress* that day, "or is it the common impulse of human nature, that when we find ourselves in command of a great force, by means of which stupendous results can be produced for the benefit of mankind, our first desire is to play tricks with it? No sooner were we alive to the extraordinary fact that it was possible, without connecting wires, to communicate with a station which was miles away and quite invisible to us, than we began to send silly messages, such as to request the man in charge of the Kingstown station to be sure to keep sober, and not to take too many whisky-and-sodas.

"Playing in this way with the great invention probably enabled us to realize better the means at our command than we should have done if the mail boat, which passed us during the afternoon, had gone aground on the Kish Bank, and we had been able to avert a catastrophe by sending the news to shore. What really impressed us most of all was the fact

that by depressing a key at Kingstown it was possible to ring a bell on the *Flying Huntress*, lying out in the neighborhood of the Kish light. It is on the same principle that one is more impressed by seeing a steam-hammer crack a nut than by seeing it crush a ponderous mass of ore."

The race drew to its close and finally the Dublin populace received the last exciting message: the *Bona* had won.

Instantly the presses of the *Daily Express* and the *Evening Mail* began to turn out papers carrying the full story of the contest. And long before the competing yachts had reached harbor the papers were being cried on all the corners of the city. The *Flying Huntress* had transmitted more than 700 messages.

When *The Yachtsman's* issue of July 28th appeared it carried an account of the race, and special mention of the method by which the townspeople followed it in the very heart of Dublin. "Indeed," *The Yachtsman's* reporter concluded, apparently willing to recognize wireless as a necessary adjunct to yacht racing in the future, "there seems to have been no reason that the report should not have been made from any one or all of the competing yachts."

Marconi had proved that he could transmit from a moving vessel, and his proof had been accepted wholeheartedly. The man in the street—at any rate, in the Dublin streets—had seen what wireless could do, and he was willing to agree that it was a sound and gratifyingly quick way to get his news. But, even more important than that, the all-powerful press had had a striking example of the usefulness of this new invention. London editors learned with interest and awakening curiosity of the speed with which news had been transferred from a tug rocking off the Kish Bank to the ink-wet

pages of the *Express* and the *Mail*. And James Gordon Bennett, editor of the New York *Herald*, received a rush message from one of his reporters: this young fellow Marconi, and his new invention, could be very useful to a paper—very useful indeed. Bennett read the suggestion carefully and filed it away; he thought probably his reporter was right.

CHAPTER EIGHT

MESSAGE ACROSS THE CHANNEL

THE FLOOD of publicity that followed the successful reporting of the Kingstown regatta led directly, the following month, to a further experiment which yielded even more recognition and good will for the wireless company—and, undoubtedly, a tremendous amount of satisfaction for Marconi.

Queen Victoria's eldest son, the Prince of Wales—later Edward VII—had injured his knee and was forced to spend a period of rest and recuperation aboard the royal yacht, *Osborne*, lying at anchor in Cowes Bay on the northern shore of the Isle of Wight. The queen herself was in residence at Osborne House, Cowes.

According to Marconi, it was the Lord Lieutenant of Ireland who came to the young inventor to ask if it might be possible to establish wireless communication between the yacht and the royal residence. Victoria, always a devoted mother, would be grateful if she might have regular word of her son's progress. Marconi assured him that such an arrangement would be a simple matter, and before long he found himself established on board the *Osborne*, in the company of the Prince of Wales, the Princess Louise, and the Duke of York. Sending and receiving apparatus were set up on the ship and at Osborne House, and communication was instantly established.

The Prince of Wales watched with great interest as the first message was dispatched:

THE PRINCE OF WALES SENDS HIS LOVE TO THE QUEEN, AND HOPES SHE IS NONE THE WORSE FOR BEING ON BOARD YESTERDAY.

"So that's all there is to it," he said admiringly. "Remarkable, Mr. Marconi—really remarkable."

Young Marconi lost his austerity in the warmth of the royal approbation, and felt that his invention had been honored indeed when the prince himself insisted upon pressing the key and sending out the miraculous dots and dashes.

Toward the end of his 16-day stay on board, the yacht cruised in the nearby waters, and, to the further admiration

of his hosts, Marconi's wireless continued to function admirably. They were never farther than seven miles from Cowes—an unimpressive span in comparison with Marconi's achievements by that time—but the youthful Guglielmo was perfectly content to abandon further experiments for greater distance as long as his wireless could be of service to the rulers of England.

A total of 150 messages were exchanged, and although they were monotonous in character, he never tired of tapping them out:

H.R.H. THE PRINCE OF WALES HAS PASSED ANOTHER GOOD NIGHT AND IS IN VERY GOOD SPIRITS AND HEALTH. THE KNEE IS MOST SATISFACTORY.

H.R.H. THE PRINCE OF WALES HAS PASSED ANOTHER GOOD NIGHT AND THE KNEE IS IN GOOD CONDITION.

Marconi himself was not, of course, the only one to be impressed by this occasion. With great solemnity the London *Times* printed the bulletins just as they had been transmitted by wireless, and all England looked with greater interest upon a young man who was able to please the royal family.

Finally, when the momentous little visit was over, the Prince of Wales expressed his appreciation by the presentation of what Marconi later wrote of proudly as "a souvenir in the shape of a very handsome scarfpin" and then—to cap the climax—the queen herself received the inventor and expressed her admiration of his work.

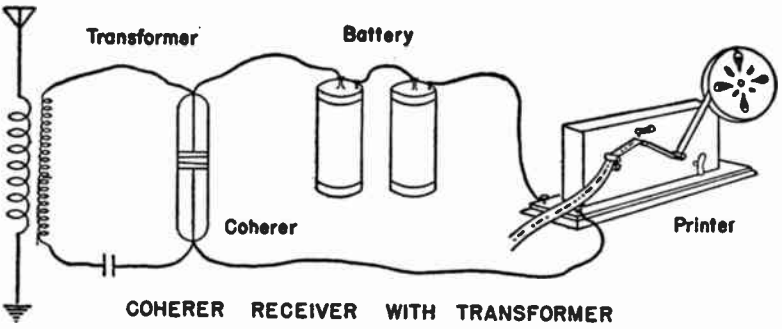
Round, solid little Queen Victoria ruled England over the long dramatic period which gave the world some of its greatest scientists. In every direction knowledge was being extended into new fields. But Victoria had little interest in such things. She thought of herself as the mother of her

people, and she loved them all; but she made little attempt to understand what some of the more brilliant of her children were achieving. Wireless was undoubtedly a most interesting invention, but it had proved its worth to her simply because it kept her informed of the progress of the prince's recovery. She did not try to ask intelligent questions about it; it was enough that she had found it useful. And it was enough for Marconi that she approved.

But when he returned to his job the problem he had determined to solve absorbed all his interest once again: his receiver must be made more sensitive. So far he had been increasing the distance of his reception by increasing the height of his aerial and the power of his transmission. But he feared the limits of practicality had been reached insofar as high aerials were concerned, and he was not yet ready to attempt still more powerful transmitters. Hence the only way open to him was further improvement of the receiving end of his apparatus. His plan was somehow to multiply the strength of the weak signals that struck the aerial, transforming them into stronger signals before they should reach the coherer to which the aerial was connected.

And so he put himself to work, designing a sensitive transformer. It had to be very sensitive indeed, for the fragile signals that struck the aerial would not affect an ordinary transformer. It was some time before he was satisfied with his results. His improved device consisted, like all transformers, of two coils, one over—or very near—the other. One coil—the primary, with its few turns of wire—was connected to the aerial at one end and to the ground at the other; the secondary coil, of many turns, was connected to the coherer; and the principle of Faraday's induction coil was of course utilized. The aerial sent weak, low-voltage signals through

the primary coil; and in the secondary coil high-voltage signals were induced which the coherer was more easily able to detect.



COHERER RECEIVER WITH TRANSFORMER

In the meantime the Wireless Company was endeavoring to extend the success it had had with such installations as that between the Rathlin Island lighthouse and the town of Ballycastle. If wireless could connect a lighthouse to the mainland, it should be able to perform the same service for a lightship. Many of those lonely, rocking crafts lay off England's coast, standing guard over treacherous rocks and shoals. Completely cut off from the mainland, and without even the security of the rock on which a lighthouse stands, they were dramatically isolated from the rest of the world. Many attempts had already been made to connect them to the shore by means of submarine cables, but the pitching of the ships in a storm usually broke the connection almost as soon as it had been made. If it could be proved that wireless might do the job, a great need would be filled—and, at the same time, a good contract would be opened up for the company.

The lightship officials granted the request for an opportunity to make a trial installation, and offered the use of the South Foreland lighthouse at Dover, and any of the nearby

ships. Marconi chose the *East Goodwin Lightship*, because it lay farther from the lighthouse than any of the others—a full 12 miles distant. On the Christmas eve of 1898 equipment was loaded into an open boat and successfully landed at the lightship; by the end of the afternoon it had been rigged up and communication was established that night.

The apparatus on board the ship, similar to the others in use at that period, consisted of a spark coil operated from a series of dry batteries; an 80-foot high aerial was fastened to the mast of the ship. In the South Foreland lighthouse similar apparatus was installed, except that the aerial was considerably higher. In fact, it was much higher than it needed to be for that job, because Marconi had in the back of his mind a plan to use that transmitter soon in an attempt at trans-channel communication to France.

The winter of 1898 was a severe one, and the *East Goodwin*, located over one of the most dangerous shoals on the coast, had more than its share of storms. Fortunately the members of the crew had learned to operate the transmitter, for the Marconi man on board was a bad sailor; and when the waves ran high he hurried below decks and left the sailors to take over his job. All through the violent winds and rains that ripped down land telegraph wires and ruined submarine cable installations, the *East Goodwin* kept its spark flashing without trouble of any kind. And in January, when trouble did come—when a huge wave ripped a section of the ship's bulwarks away—the wireless flashed the news to South Foreland lighthouse and help was sent. It was the first use of wireless to report an accident at sea.

The British Navy had perhaps been slow to appreciate the invention of Marconi, but now, aware of its recent uses, it presented its own request for a demonstration. Consequently

three ships of the B fleet were fitted with wireless equipment—the flagship *Alexandra* and the cruisers *Juno* and *Europa*—and a test was made during the 1899 spring maneuvers. Marconi himself went aboard the *Juno* to watch the performance of his apparatus during a simulated attack. Throughout all the complicated course set for the ships, through fog and rain and the darkness of night, the three ships maintained communication with each other up to a distance of 78 miles. The exercises ended with a victory for the B fleet, and Admiral Sir Henry Compton Domville publicly attributed to wireless a great share of the victory.

And now Marconi could wait no longer to try out the plan that he had been working toward for some time. The South Foreland lighthouse aerial was ready for him, and he wanted to use it. The distance across the channel was only about 30 miles at that point, and, as an official of the Wireless Company said, "We are doing a parallel distance today without the slightest difficulty. The sea between Calais and Dover is the same sea as between the Isle of Wight and Poole, so the things being equal in both cases we may expect the same success between Calais and Dover as between the other two points." The only thing needed was the permission of the French government to erect another station at Wimereux, a small town about three miles from Boulogne on the northern coast of France.

While the negotiations with the French were going on, the apparatus on board the *East Goodwin* had its first opportunity—indeed, it was the first opportunity ever offered wireless—to save human life. The English Channel is a tricky body of water at best, and when the wind rises to any degree it becomes worse; fog hides the lights and the air is filled with the foghorns' bellow for hours at a time. Up the

channel on March 3rd, 1899, a steamer moved slowly through the murk, attempting to get its bearings from the horns that wailed on every side. One horn that sounded very close must be, the captain decided, the *East Goodwin's*. Speed was reduced in an effort to avoid the dangerous shallows of the Goodwin Sands. But the order came too late. A moment later a shudder ran through the ship that shook her from stem to stern. And then she was still—stuck fast on the sands.

Near by the *Goodwin Lightship* heard the steamer's whistle signaling: Aground! Aground on the sands in a bad blow was no matter to be treated lightly, but the ship itself was powerless to help. It could do something though. An order was given, the lightship operator turned to his wireless key, and the message went out: Ship aground on Goodwin Sands! Immediately men on shore sprang into activity; shouts echoed up and down the beach, boats were launched, and out into the surf they headed, called to their errand of rescue by the invisible waves a snarling spark had created many miles away. All the crew of the grounded steamer were rescued, and a cargo worth more than £50,000 was saved from the angry sea. Wireless had come through its first life-saving job with flying colors.

Not long afterward the *S. F. Mathews* collided with the *East Goodwin*, during another fog; and once more wireless did a critical task quickly and well; once again lives were owed to the miracle of the electric waves.

While the newspapers were still buzzing with these latest exploits of his invention, Marconi received the approval of the French government for the erection of a station at Wimereux, and crossed the channel to oversee the construction. Officials who visited the station often during the

next weeks were amazed to find the young Italian, already a famous man, clad in overalls and hard at work digging a hole in the ground for his mast, laying bricks, or laboriously hooking wires together. Marconi liked to participate in every phase of his work; he had done everything that needed to be done for the experiments in his father's garden, and he still liked to feel a part of every installation that the company made.

Monday, March 27th, saw the arrival of French dignitaries to witness an important event. With a cautious hand on their high silk hats, they bent their heads far back to look at the 150-foot pole that supported the aerial. *Eh bien*—so that was what it looked like! And then they went into the wireless room where Marconi was preparing for the test.

Just as the clock on the wall indicated five o'clock, his hand pressed the key. There was a sharp crack, and the blue spark began its dance. The eyes of the visitors blinked in the sharp blue light that put to shame even the setting sun of what had been a bright spring day. *Eh bien*—so this was what *they* looked like! Suddenly Marconi stopped, flipped the aerial switch, and sat back to wait for his answer. He was probably the only person in the room not in the least concerned about the outcome of the experiment; he knew it would work. In a moment there was a click from the coherer, and the telegraph printer began to unroll its tape.

That's all there was to it. With a flick of his wrist Marconi had thrown words across the English Channel. Just as easily the operator at the South Foreland lighthouse had answered him. And France and England stood united by wireless.

After sufficient messages had been sent and received to convince the visitors that wireless worked consistently, Marconi and some of the officials embarked on the night boat

from Boulogne to see how the experiment operated from the English side of the channel. Kemp, left at Wimereux, received as one of the first messages sent by Marconi from South Foreland the following day, a communication to Professor Branly, the Frenchman whose coherer had played so large a part in Marconi's success:

MARCONI SENDS M. BRANLY HIS RESPECTFUL COMPLIMENTS ACROSS THE CHANNEL THIS FINE ACHIEVEMENT BEING PARTLY DUE TO THE REMARKABLE RESEARCHES OF M. BRANLY.

On the same day, March 28th, the Boulogne correspondent of the London *Times* made history by sending out the first foreign news dispatch transmitted by wireless—a description of the new system of communication. And a few days later another sort of reporter arrived to help spread the news of Marconi's progress. Cleveland Moffett, a writer for the American *McClure's* magazine, had come to Boulogne while Robert McClure, publisher of the periodical, went to the lighthouse station. The two men were determined to prove to themselves whether wireless could do all that had been claimed for it. They were going to communicate with each other, by a prearranged plan, in such a way that the accuracy of wireless would be—they thought—severely tested.

Kemp smiled at the message Moffett handed him to be transmitted to his employer across the channel:

MC CLURE, DOVER: GNITEERG MORF ECNARF OT DNALGNE HGUORHT EHT REHTE—MOFFETT

Did Moffett believe that spelling words backward would confuse the transmitter or the receiver? He tapped it out just as it had been given to him, and in a few moments he had his reply:

MOFFETT, BOULOGNE: YOUR MESSAGE RECEIVED. IT READS ALL RIGHT. VIVE MARCONI—MC CLURE

And, once convinced, McClure did his best to persuade the readers of his magazine that Marconi was a young man to be admired and trusted. He had already printed the first magazine article to herald the Italian's invention in America; now he undertook a series of articles that covered Marconi's progress and did much to keep him before the eyes of the country across the ocean.

All of the visitors to Wimereux were not so helpful. W. W. Bradfield, one of Marconi's assistants, was on duty at the station one night when the quiet room was disturbed by an uninvited guest—a wild-eyed man who rushed in with a revolver waving over his head, shouting that the wireless waves in the air had given him severe internal pains.

"I'll shoot! I'll shoot!" he insisted hysterically. "If you don't stop that thing this minute I'll shoot."

He was scarcely in the mood for reasonable argument, so Bradfield, with one eye on the gun now pointed directly at him, said soothingly that he had heard of other people being affected in the same way.

"It is unfortunate," he said. "But now that you have come here, you will be all right. We possess the cure for this ailment. One treatment and you will never again suffer from the air waves."

The gun wavered. "A cure? What sort of a cure?"

"Quite simple," Bradfield assured him. "We give you an inoculation against them. If you will just step over here—that's right. Now, you will feel a slight sense of shock, but you will never again be troubled by the pains."

The man had moved slowly toward him, but the gun was still in his hands.

"Oh, yes," Bradfield said casually, "there is just one thing. The cure will not be effective if you have any metal on your person while it is administered. Would you put your watch here on the table—and any change you happen to have in your pocket? That's fine, thank you. Oh—and you'd better put the gun down too. It wouldn't be safe with the gun."

Obediently the man laid the weapon down, his misguided rage now forgotten in his growing interest. And Bradfield, with a sigh of relief now that his life was no longer momentarily in danger, gave the sufferer a shock of electric current.

"There! Now—you feel better already, don't you?"

"Why—why, yes. I guess I do." And completely calm once more, completely satisfied, he put his gun in his pocket together with the rest of his belongings and departed.

Lord R. S. S. Baden-Powell, the founder of the Boy Scouts, was another Wimereux visitor, and Marconi spent much time explaining this apparatus to the old soldier. Late one night the two men decided to communicate with South Foreland. Casually Marconi clicked off a message and waited for a reply. But none came. He tried again—and still there was no answer. A puzzled look appeared on the inventor's face and his guest, well enough acquainted with wireless now to realize that this was a strange situation, joined him at the table in troubled silence. Marconi checked all his connections carefully and then tried once more. Silence.

Together they went outside into a raging storm and inspected the wires that led to the aerial. There seemed nothing wrong there. So they reentered the station, installed a new coherer, and tried again. But still there was no answer to his flashing sparks.

The puzzlement on Marconi's face had given way to a

grim look. And Baden-Powell began to feel embarrassed. Perhaps the principles of wireless telegraphy were somehow not permanent. Perhaps, for some unknown reason, wireless would never work again. After all, very little was known about electricity. Perhaps—

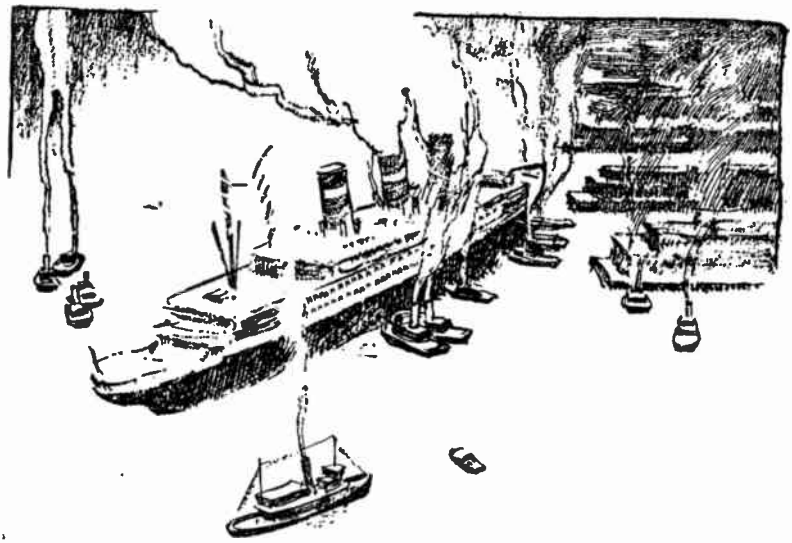
Marconi marched out into the night again, and his guest stubbornly accompanied him. This was no time to leave a man, when his future looked as black as the sky over their heads.

"I could try—"

But Marconi was interrupted by a shout from a mechanic inside the station. "South Foreland!"

When they tore back inside a moment later the coherer was clicking merrily and the tape was jigging off its spool on the Morse printer. Together they read:

JUST BACK FROM SUPPER ANYTHING HAPPENING YOUR END?



CHAPTER NINE

FIRST TRIP TO AMERICA

WITH THE successful bridging of the English Channel in March 1899, wireless began to feel the first real stirrings of growth toward an international system. The stations at South Foreland and Wimereux became a mecca for visitors from all over the world. Representatives from as far away as China and Brazil braved the blustering wind that seemed always to be on hand to greet the inventor's most distinguished guests.

The reception of delegations became, in fact, because of that wind, something of a problem. A visitor who had chased his bowler hat for a quarter of a mile was not in the mood to be impressed with the sight he had traveled so far to see; and Marconi himself, often appearing in the role of host with his sleeves rolled up and his face streaked with black, did not serve to restore him to a ceremonial frame of mind. There

were never formal receptions at Wimereux or South Foreland; there were instead cozy gatherings around an old stove, with bread and cheese and bottles of beer spread out on a bare wood table. A visiting dignitary, assaulted by these startling departures, sometimes left less awed by wireless than he had expected to be. And sometimes too he carried away with him and reported abroad a picture of Marconi as a strange sort of man. After all, an internationally-known figure ought to make some effort to behave as people expected him to behave.

But the visitors who were themselves scientists recognized Marconi instantly for the hard-working earnest student he was. And the members of his staff were always loud in his praises. They emphatically denied the widespread feeling that Marconi was a difficult man to know. Difficult? Nonsense. Why, he was just like the rest of the engineers—no airs about him, none of this acting-important business just because he was the boss. The peasants on Giuseppi Marconi's estate would have known what they meant, even if the foreign diplomats did not. Yes, Marconi was still a good man to work with—because you never felt as if you were working *for* him.

And there was a lot of work to do in 1899. Communication between ships and land stations was an accomplished fact. Shipping companies, quick to appreciate the value of even the 100-mile wireless range that was then possible, began to install Marconi equipment on their boats in ever-increasing numbers. And, to improve the usefulness of the ship service, Marconi began to erect land stations at a number of places along the English coast.

When the Boer War broke out in the fall of that year, British government officials discussed the potential value of

wireless on the battlefield. And finally, after long consultations, Marconi sent five of his assistants to South Africa to see what they could do. The results were not too encouraging. Climate and geography were entirely different from that in the familiar experimental districts in England; it was necessary to use kites instead of poles for raising their aerials; and consequently reception was uncertain. But the attempt was not an unqualified failure. It served at any rate to increase the fund of information which was so necessary to the future of wireless.

While that experiment was being made, Marconi received encouragement from another source, and a new opportunity to put wireless through its paces in the bright light of publicity. James Gordon Bennett of the New York *Herald* had not forgotten the advice of his reporter after the Kingstown regatta. Almost immediately he had cabled to Milton V. Snyder, who had gone to Paris from Ireland:

> GO BACK TO LONDON AND MAKE ARRANGEMENTS FOR MARCONI TO GO TO NEW YORK IN SEPTEMBER TO REPORT THE AMERICA CUP RACES FOR THE HERALD.

Snyder had discussed the matter with Colonel Davis and that gentleman, aware of the glory that would attach to anyone sharing in the limelight of those famous international races, had been enthusiastic. But Marconi had hesitated at first. He hadn't been quite sure he could do the job successfully, and he was too cautious to attempt something he knew might fail. He finally agreed that if the channel communications went according to schedule, he would accept the offer.

The channel had been crossed, he was sure of himself now, and the time had come to fulfill his promise—and to see America.

On September 11th, 1899, Marconi sailed from Liverpool on board the *Aurania*, with William Goodbody, a London director of his company, and three skilled Marconi operators —Charles E. Rickard, W. W. Bradfield and William Densham. The *Aurania* docked on the 21st.

New York was in a fever of excitement just then over Admiral George Dewey, hero of the Spanish-American War so recently concluded. Dewey arrived in the city almost simultaneously with the young inventor, and plans for his reception had been made with hysterical enthusiasm. It would not have been surprising if Marconi had been lost sight of completely in the program of dinners, parades and street celebrations that had been long planned in honor of the dramatic figure of Manila Bay. But the *Herald* would not permit that to happen. Marconi had been brought to the United States at some expense, and Bennett did not intend to let his money go to waste.

Full pages of pictures—line drawings, they were, in the somewhat florid style of the period—and printed matter heralded Marconi's arrival and reported his every move while he was in New York. The issue of September 22nd carried a reporter's impression of the young Italian:

> When the passengers began filing down the gangway from the Aurania few of the many who were on the pier recognized in the youthful, almost boyish-looking, man the bearer of a name that has become distinguished in electrical circles. Signor Marconi looks the student all over and possesses the peculiar semi-abstracted air that characterizes men who devote their days to study and scientific experiment.

Marconi had recently grown a mustache and it is possible that he was growing tired of being referred to as "boyish-looking." On the other hand it is doubtful if he preferred

another newspaper description of himself, in spite of the fact that the grown-up mustache was given due recognition:

> When you meet Marconi you're bound to notice that he's a "for'ner." The information is written all over him. His suit of clothes is English. In stature he is French. His boot heels are Spanish military. His hair and mustache are German. His mother is Irish. His father is Italian. And altogether, there's little doubt that Marconi is thoroughly a cosmopolitan.

Youthful in appearance he might be, but he soon impressed the reporters with his calmness and his self-assurance.

"Do you really expect to send wireless messages to shore from a ship somewhere out in the Atlantic?" he was asked.

And Marconi answered with the quiet air of a man who knows exactly what he is talking about. "We will be able to send the details of the yacht racing to New York as accurately and as quickly almost as if you could telephone them. The distance involved is nothing nor will the hill interfere."

"What about our skyline, Mr. Marconi? What do you think of New York's tall buildings?" They put the question which even in that year was standard fare for recent arrivals.

Marconi glanced up for a moment and then smiled. "Well, I don't think they'll stop the wireless waves—if that's what you wanted to know." Whether that was the answer they expected or not, it was the only one they were to get; Marconi saw all heights as obstacles that his waves could or could not overcome. And New York's didn't frighten him.

That night there was an explosion in the Hoffman House, where he was staying. Immediately anxious guests inquired whether it had been caused by the strange-looking machinery brought in by that young man. The manager's assurances only half-placated them; always there were to be frightened men and women shying away from Marconi;

like the gun-brandishing stranger who burst into the Wimereux station, they didn't understand wireless but they expected the worst.

Marconi laughed aside the story. He had a serious trouble to concern himself with: it had just been discovered that one trunk of equipment was missing. When a frantic search proved it definitely lost, Marconi let his usually well-controlled Italian temperament get the best of him. That trunk contained the coherers and other necessary parts. It would be impossible to replace them, of course. And he announced that he would return to England on the next boat.

It had been Bradfield who invented the "inoculation cure" for the pains brought on by electric waves. Now it was Bradfield again who kept his head in an emergency. He remembered that another ship had left Liverpool on the same day that the *Aurania* sailed. It was possible that the trunk had somehow found its way aboard her instead, and was now safe—but unfortunately distant—in Boston. The hunch was worth following up. The *Herald* management, as upset as Marconi over this threat to their lavish plans, dispatched a reporter immediately. And back he came, triumphant, the trunk beside him. Bradfield had been right.

A little sight-seeing was enough for Marconi. He wanted to get to work. And so, after a perfunctory round of the city, during which he seemed chiefly impressed by the swiftness of New York's elevators, the job of installation got underway. The Highlands at Navesink, overlooking Fort Hancock, New Jersey, were selected as the site for the receiving station, and Bradfield took charge of the work there under the sceptical eyes of lighthouse keepers and Signal Corps men from the nearby fort. The *Ponce* of the Porto Rico Line and the *Grande Duchesse*, an ocean-going steamer,

were chartered for the rest of the equipment. Aerial poles 150 feet high were erected at both the shore and ship stations.

By October 1st Marconi was ready to make a trial run on the *Ponce*, and everything seemed to be in order. He sent and received signals from the location of the race course, and the distinguished guests on board amused themselves sending personal messages to New York. One of them made a date for dinner that evening, which he kept on time 22 miles from the point where his invitation had been issued.

That night there was an informal dinner in Marconi's honor. According to the newspaper story the following day, the inventor "needed little urging to persuade him to take a seat at the piano, of which he is a master. He caressed the keys with a touch quite as magical as that which gave him control of the currents of the upper air." Marconi was growing famous indeed, if a few casual airs with which he tried graciously to amuse his hosts were subject for such pompous compliment from the press.

Two days later the *Shamrock* of Sir Thomas Lipton and the *Columbia* of C. Oliver Iselin stood at the starting line to carry on the rivalry which had begun all of 48 years before, when an American yacht proved itself superior to all competitors in a race around the Isle of Wight. Feeling ran high, and Marconi, a yacht enthusiast himself, was more excited over the outcome of the race than the success of his own part in it—but then, he was confident of his success.

But the next day the *Herald* headlined: NO RACE. The wind had failed, and the two gallant ships had lain almost unmoving in the smooth water. Marconi had fared better. He had sent messages to Bradfield, who relayed them by telegraph to New York, and when the bulletins were posted

on the *Herald's* boards most of the last American sceptics subsided.

Several more days went by. The weather continued to hamper the great race, but nothing stood between Marconi and national enthusiasm. Telegrams from San Francisco arrived, and from many points between that far-distant city and New York. The United States, always interested in everything that was new in the world of science, had taken Marconi to its heart.

On October 5th, while heavy fog blanketed the harbor, a rumor somehow sprang up in New York that the *Grand Republic*, one of the ships following the course of the race, had gone down. She was heavily loaded with racing enthusiasts, and when the word flashed around the city hundreds of concerned friends and relatives of those on board clamored for information. A minor panic was being born.

Quickly the *Herald* wirelessed to Marconi. And instantaneously he sent back reassuring word. The *Grand Republic* was safe. He had just seen her. Marconi's popularity took another leap.

In fact, so fervent was the interest in the wireless that reservations on the *Ponce* and the *Grand Duchesse*—both of which carried guests for the days of the race—were almost impossible to obtain. They were luxurious ships, both of them, specially fitted out for this momentous occasion; New Yorkers had their first taste that week of the luxury of ocean travel without its previously attendant danger of complete isolation from shore.

The *Columbia* finally won the long-drawn-out contest. Marconi had sent a total of 1,200 messages and he was a national hero. The *Herald*, proud now to make space for

Marconi in spite of the other stirring news of the day—the *Oceanic*, "latest wonder and new giantess of the sea," had just reached New York on its maiden voyage; Dewey was still being the subject of innumerable columns; and Robert Peary had been attempting to reach the North Pole—the *Herald* now calmly assumed that Marconi was one of the important stories of all time.

> The possibilities contained in the development of telegraphy without the use of wires are so important [it declared] that any step tending to bring the system before the public and to show what it is capable of accomplishing in a commercial way must be of interest not only to those interested in science, but also to everyone who sends a telegram.
>
> The tests stimulate the hope that the man of the coming century may be able to "halloo his name to the reverberate hills" and irrespective of distance or material obstacles "make the babbling gossip of the air cry out" in intelligible speech.

Marconi took the time to assist with some tests of wireless equipment on the cruiser *New York* and the battleship *Massachusetts*, for the United States Navy; and the installation of communication between Fire Island and *Fire Island Lightship*, approximately 12 miles away, for the Signal Corps of the Army. Neither performance was particularly dramatic and apparently both the Army and Navy were able to regard wireless with less enthusiasm than the non-uniformed section of the public.

Now Marconi could go home and now he was ready to go. The trip had been a pleasant vacation, and it had been valuable to him as publicity. But all the publicity in the world could do him no good unless he continued to have improved equipment to publicize. He was ready to get back to work. Quietly he boarded a boat and returned to England.

Much awaited him to do when he disembarked. The increasing number of shore stations ringing the British coast were causing a great commotion in the air. Signals were beginning to interfere with each other; messages were being scrambled. The 25-year-old Marconi faced one of his most serious problems: the achievement of transmission that was at one time secret, or private, and that was intelligible in the hodge-podge of the air waves that grew daily more confusing. The coherer of that day was much too hospitable a device: it accepted any signal that came its way. It would have to be taught to accept only one signal at a time—the right one.

But before the coherer could be taught to reject many signals and accept one, it was necessary to devise transmitters which would send out signals that varied from each other. The signal from South Foreland, for example, would have to differ in some way from the Alum Bay dots and dashes. And how was that possible?

Marconi knew that the one feature of an electric wave which could be changed was its length. The size of the spark balls and the distance between them roughly controlled that length—but only roughly. Some other, more accurate, method of control would have to be devised if he wished to utilize that fact. And that method would have to be applicable to the coherer as well as to the transmitter; for what good would changing the wave length of a transmitter do, if the coherers continued to accept waves of all sizes?

The idea of regulating the wave length of the transmitter and tuning the coherer to that wave length was not new with Marconi. Sir Oliver Lodge had, in 1897, patented his plan for doing this under the title: "Improvements in Syntonized Telegraphy Without Line Wires." Lodge had put

forth the theory that *capacity* and *inductance* controlled the length of a wireless wave; and he had also reasoned that unless a receiving set had the same capacity and inductance as a given transmitter, it would not be able to receive that transmitter's waves.

Capacity is given to a circuit by the use of condensers, and a condenser is nothing more or less than two conductors of electricity separated by an insulator. Two sheets of tin foil pasted on opposite sides of a sheet of wax paper make a condenser; the larger the area of the tin foil, the larger the capacity the condenser will have.

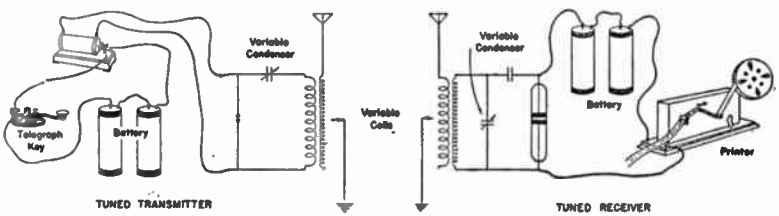
Inductance is given to a circuit by the use of coils. Wrapping many turns of wire around a cardboard oatmeal box was the simple and most popular method of winding a coil in the early days of radio, when all boys constructed their own crystal sets. By varying the length of the coil, the crystal set could be made to respond to various wave lengths and thus tune out unwanted stations.

Lodge's patent described a system of obtaining capacity in transmitting and receiving circuits by means of conical-shaped radiators attached to the spark balls and to the coherer. These radiators would act as condensers. If they were of equal size on a transmitter and coherer, that transmitter and coherer would be in tune with each other, because they would have the same capacity.

Marconi realized that Lodge had discovered the basic principles of tuning, but he also realized that the older man's radiators were impractical. For one thing, Marconi was using larger and larger aerials, and it would have been impossible to replace them with radiators of equal size. Secondly, Marconi desired some means of changing the wave length of a transmitter or a receiver without employing a variety of Lodge

radiators. He wanted to accomplish his change by the turn of a wrist. In other words, Marconi recognized the need for what is known today as a tuning dial, and with his usual ingenuity he set himself to fill it.

First he constructed some condensers of variable capacity —that is, adjustable condensers. Then he designed coils that were also adjustable, thereby creating an adjustable inductance. When these coils and condensers had been hooked into both a transmitting and a receiving circuit, he had achieved his purpose. He merely adjusted his transmitting station to



TUNED APPARATUS

a wave length he wanted and, by turning the dials and adjusting the inductance and capacity of his receiver to meet that of the transmitter, forced the coherer to reject all but the one wave length.

The patent which Marconi filed in 1900 to protect his improved tuning idea is probably one of the most famous in wireless history. It has been attacked in the courts of many countries, and in every case Marconi's rights were upheld. Lodge's patent, however, had been upheld in many courts as the basic tuning patent in wireless; realizing this, the Marconi company purchased the Lodge patent in 1911, although Marconi never utilized Lodge's system as outlined in the Englishman's patent. But the Marconi patent, No. 7777—the "four sevens," as it is called—together with the Lodge patent, gave the Marconi company an almost complete

monopoly of tuned wireless in England and America for some time.

Of course those who had most strongly maligned Marconi's wireless for not being secret and selective doubted that his new tuned apparatus would actually work. And tuning was not a simple thing to explain to people who had no knowledge of electricity. It was all very well to explain wireless waves by saying that they were like the ripples on the surface of a pond, and that the receiver was like a chip floating on that pond; when the ripples reached it, the chip bobbed up and down, *detecting* the presence of the waves. But how could Marconi explain his "educated receiver"—a chip that would bob up and down only in response to certain ripples and no others?

He decided to demonstrate his new system in such a way that all doubts would be ended once and for all. He would connect two transmitters, each with a different wave length, to one aerial; and two receivers, one tuned to one transmitter and one to the other, to another aerial. In a letter to the London *Times* Professor James A. Fleming described the dramatic exhibition Marconi put on (later duplicated over an even greater distance—from the Isle of Wight to a station in Cornwall 156 miles away):

> Two operators at St. Catherine's, Isle of Wight, were instructed to send simultaneously two different wireless messages to Poole, Dorset, and without delay or mistake the two were correctly recorded and printed down at the same time in Morse signals on the tapes of the two corresponding receivers at Poole.
>
> In this first demonstration each receiver was connected to its own independent aerial wire, hung from the same mast. But greater wonders followed. Mr. Marconi placed the receivers at Poole one on top of the other, and connected them both

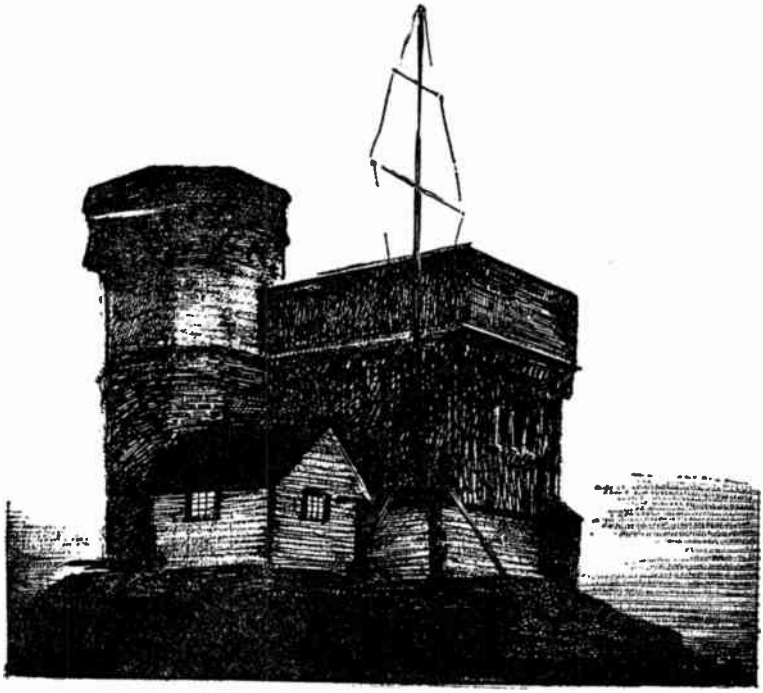
to one and the same wire, about forty feet in length attached to the mast.

I then asked to have two messages sent at the same moment by the operator at St. Catherine's, one in English and one in French. Without failure, each receiver at Poole rolled out its paper tape, the message in English perfect on one and that in French on the other.

When it is realized that these visible dots and dashes are the result of trains of intermingled electric waves rushing with the speed of light across the intervening thirty miles, caught on one and the same short aerial wire and disentangled and sorted out automatically by the two machines into intelligible messages in different languages, the wonder of it all cannot but strike the mind.

. . . So perfect is the independence that nothing done on one circuit now affects the other, unless desired.

Marconi had successfully "educated" his coherer. And he had effectively demonstrated the new and miraculously improved instrument.



CHAPTER TEN

POLDHU—25,000 WATTS!

As THE new century opened up, wireless was abandoning its early creeping pace, and was moving ahead by leaps and bounds. The Hertzian waves had flourished under Marconi's careful hand until 150 miles meant little to wireless communication. Coupled with this achievement was the undeniable new one—that wireless waves could now be sorted out and prevented from indiscriminately pouring down the aerial of any receiver within their range. Marconi had even constructed what was probably the first portable radio transmitter and receiver: an apparatus built into a steam-powered automobile equipped with a metal cylinder on its roof to

serve as an aerial; in lieu of a ground connection he had arranged a strip of wire netting to drag along the ground; and with this he communicated over a distance of 31 miles.

All this was very gratifying to the Marconi company. It was more than gratifying—it was actually beginning to be financially profitable. The British Navy had installed Marconi equipment on 26 of its ships and had instructed the inventor to build six land stations for their use. Lighthouses were tied to the land by wireless installations. And Lloyd's was using the "etheric wave" more and more as a source of valuable reports on incoming ships.

All in all, the directors of the company looked rather contented as they gathered for a meeting in the early days of the twentieth century. Their contentment grew as they listened to the reports that were read to them, and they smiled over at Marconi where he sat quietly in his own place. Marconi himself said little throughout the discussion that followed, answering questions that were put to him but making his answers brief. And then, in the ensuing quiet, he got to his feet.

"Gentlemen," he said firmly, "the time has come to act."

"Act?" One of the gentlemen smiled at him warmly. "I think we're acting pretty effectively as it is."

"Acting effectively, perhaps, but not progressing."

"Really, Mr. Marconi," another member came to his fellow-director's assistance, "I should certainly think that the reports today indicate considerable progress being made."

Marconi nodded pleasantly. "Yes, a good deal of progress has been made in extending our service to more clients. But now wireless must make more progress in a scientific sense. The time has come for it to put off its swaddling clothes. Puny sparks have no place in our plans any longer. Power

from batteries was sufficient in our early experimental days but now, gentlemen, we have passed the stage where 250 watts is enough. We need power—more power."

How ambitious he was—and how hard-working. They regarded him as fondly as if he had been their son. And how much he had done—and was going to do—for all of them. They had only to sit comfortably by and soon, they all felt reasonably sure, they would be making almost more money than they knew what to do with. So they were very indulgent with him now. If he wanted more power he should have it.

"It shouldn't be difficult, Mr. Marconi, to add some more batteries to your system and raise the power to 500 watts—or even to 1,000 watts, if necessary. You must spend what you need on your equipment."

Marconi smiled and waited a moment before he spoke again. When he did his tone was quiet. "I'm afraid you misunderstand me, gentlemen. I don't want 1,000 watts—or even 5,000 watts. What I have in mind is a permanent station with a power of 25,000 watts."

No one spoke for a long still minute. And then a voice whispered "Twenty-five thousand watts!"

"But—but—Mr. Marconi," another director managed, "why a station of that size? Surely you don't— That is, what could you accomplish with such a station that we are not doing now? We're doing so well at present and—"

His voice died away in the stillness.

Marconi could have told them exactly what he hoped to accomplish, some day. He could have told them of the days when he had stood staring out over the Atlantic toward the distant coast of the New World. His wireless would reach across that water some day. But he did not wish to speak of

that now; it would sound too visionary. They would be frightened. But another of his ideas—a lesser one, but still far more ambitious than anything yet attempted—he would tell them of.

"I want to build a powerful station somewhere in England," he began slowly, choosing his words. "And another in America. So that a ship leaving England can remain in communication with the first for half her trip over the Atlantic. Then, as the English signals grow weaker, she will be moving into the range of the American station. These two stations, gentlemen, will make it possible for ships to remain in communication with land for their entire voyage. That's why I need power."

"But Mr. Marconi, half the breadth of the Atlantic—!"

"Wireless is miraculous, of course, my boy, but after all—"

"Would it be wise just now to attempt so fantastic a scheme?"

The questions and the objections, politely but strongly phrased, came thick and fast. And for all of them Marconi had a sober, well-reasoned answer.

They had, the members of the board of directors, long ago willingly and gratefully accepted the fact of Marconi's genius. It was as pleasurable as it was profitable for them to sit by and watch him perform his miracles. But it was still hard to believe that this young man had a head for business equal to their own. And it was difficult to reconcile his firmness with his few years. For firm he was. He knew exactly what he wanted and he intended to have it.

"These stations, Mr. Marconi," one of them said finally, admitting defeat in the first round, "will cost a lot of money, I presume?"

"Alternating current generators of 25,000-watt capacity

are not inexpensive," Marconi agreed smoothly. And then he smiled. "But even they will not be the most costly item in my plan. We will need buildings, huge aerials, great banks of condensers and immense transformers—for I intend to use 20,000 volts for my spark. And in addition to all that I shall need the services of the best men I can obtain to help me. I want a man who can make it safe to handle that deadly amount of electricity—a man who can design the powerful station I have in mind, and another who will be able to build it to specifications."

His own calmness stilled their loudest objections. In spite of his youth, in spite of the board members' consciousness of their own wider experience, his air of sureness defeated their arguments almost before they were advanced. And when Marconi had finished talking to them at that meeting and at others that took place soon afterward, he added to his staff two men who were to be connected with him for years: the distinguished Professor James Ambrose Fleming of University College, London, one of the foremost electrical engineers of the day and already interested in wireless and its future; and friendly, easy-going R. N. Vyvyan, an engineer who had specialized in the construction of electric power plants. Fleming was assigned the task of designing the new station, and Vyvyan was to be responsible for its construction.

The next problem was that of a site. Obviously it would be wise to put the new powerful equipment on England's western coast, as close to the western hemisphere as it was possible to get. Cornwall, that long narrow peninsula that extends into the Atlantic in the south of England, was a natural choice. It was a sparsely inhabited region, and there were miles along its rocky shore where one could see no

buildings at all, nor any other man-made interference to the transmission of electrical waves.

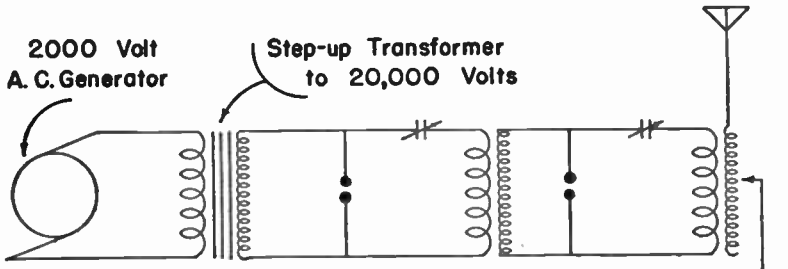
In the month of July 1900 Marconi visited the region, accompanied by Vyvyan and Major Flood Page, then managing director of the company. They spent some time touring the countryside, enjoying the strange little un-English villages and the grassy reaches that lay between them, sweet with the scent of gorse. The sea pounded roughly against Cornwall's black rocks—rocks which had proved the grave of many splendid ships, and which Marconi scrambled over now in his search for exactly the right place to build a transmitter that would, he hoped, cheat the sea of much of its spoils in the future. Cornwall was accustomed to sea disasters, and doubtless it paid little attention to a young man who had some wild dream of preventing such tragedies. Prevent them? Why, disaster was as natural to the sea as the blue of its waves on a sunny day. But Marconi didn't think so, and he went on looking. At Poldhu, facing the full wide sweep of the Atlantic, he found what he had been looking for.

Back in London proceedings were begun immediately to buy the required land and Fleming, with Vyvyan's assistance, went to work on the plans for the transmitter. Immediately unpredicted difficulties were encountered. A small telegraph key, which had successfully broken the primary circuit of the small spark coil used up to that time, was obviously unfit to handle 25,000 watts of high-voltage current, and that part of the equipment had to be changed. Furthermore, Fleming was afraid that the rapid interruption of the current necessary to manufacture the dots and dashes would, in a transmitter of this size, so strain the transformers and condensers that they would burn out; so new and ingenious methods had

to be worked out to avoid that. Fortunately Fleming was equal to the task he had assumed.

Marconi himself had a new idea of what a long-distance aerial should be, but the construction of it according to his plans would have delayed the actual tests of the new station. Consequently a temporary aerial was installed and by the middle of January 1901, Fleming joined Marconi and Vyvyan at Poldhu for the first trials.

Fleming, with his characteristic care, methodically tested



EARLY DOUBLE SPARK TRANSMITTER AT POLDHU

each piece of apparatus separately to make certain that nothing would go wrong. But in spite of all his efforts the first short-range tests showed some inefficiency in the design of the coils, and Fleming was forced to spend some four long months rearranging and rewinding them until he was satisfied that the station was ready for a real test.

In the meantime Marconi had not forgotten his plan for a second powerful station in America, and in February he and Vyvyan returned to London to discuss arrangements for it and also for the new aerial Marconi was still eager to try out. Vyvyan had not yet seen the plans for it and when he did he objected strenuously: they called for the erection of 20 wooden masts each 200 feet high, arranged in a circle

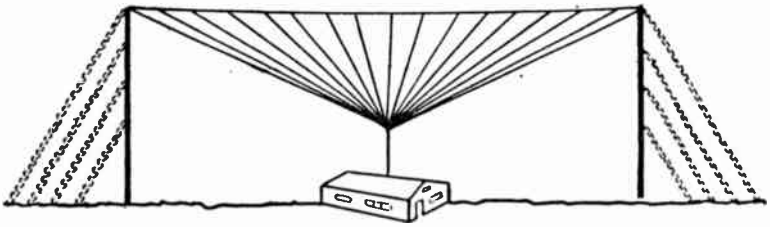
200 feet in diameter. Vyvyan insisted that it would be blown down the first time a storm occurred. But Marconi, in spite of Vyvyan's long experience as a construction engineer, clung to his original idea. And finally, by the time the two men were ready to sail for the United States to choose the site for the American station, Vyvyan's objections had been overridden.

It was on Cape Cod, the long crooked finger that Massachusetts puts out into the Atlantic, that they decided to erect the sister-station to Poldhu. It would stand on the sand dunes of South Wellfleet, facing the waves and the continent that lay beyond them. Marconi left Vyvyan in charge there and hurried back to England.

The South Wellfleet aerial went up according to Marconi's plans, but in August a light breeze almost blew down the elaborate construction of wires, and Vyvyan—his own original opinion of the design strengthened—communicated with the London office seeking permission to lower the masts. But before an answer could be sent the Poldhu aerial, newly built according to the same plan, was completely ruined in an early September gale. A week or two later a fresh breeze caused the same havoc at Cape Cod—one mast narrowly missing Vyvyan himself as it crashed noisily through the roof of the little transmitting room. Marconi, finally persuaded, gave up his design which had, he still thought, looked so well on paper.

At Poldhu they decided not to waste time trying to erect another giant aerial. Two masts 150 feet high were set up, and a wire was stretched between them. From this wire, vertical wires about three feet apart converged to a single strand at the roof of the transmitting station, so that the whole device looked like a triangle standing on its point.

Finally, after his many disappointments, Marconi was ready for a test. An operator at Crookhaven, Ireland, 225 miles away, was warned to listen for the Poldhu signal. Once more there was reenacted the little scene that had taken place so many times in the history of wireless: Marconi stretched out his hand toward the key, and the men around him stood tense with expectation. The key moved, the spark leaped—and everyone in the room instinctively covered their ears under the crashing sound.



SUBSTITUTE AERIAL AT POLDHU

At Crookhaven the operator, straining his ears to catch a faint signal, jumped from his seat with excitement. The waves from Poldhu had come through—and with such force that they almost rattled the coherer. Once more the miracle had increased its dimensions.

Marconi tested again and again, always with the same spectacular success. Finally he motioned Kemp to follow him outside, and when they were by themselves on the cliff he said quietly, "They'll cross the Atlantic—those sparks. Why shouldn't we let them?"

"The Atlantic?" Kemp's round face looked blank. "But I thought—"

"I know. But if they'll cross the Atlantic they'll reach a ship any place between here and America."

"Yes, of course." Kemp's eyes had brightened with excitement.

"This is what I want you to do."

They talked for quite a while out there, and when they returned to the station Kemp got ready to depart on a series of mysterious errands.

Marconi did not announce his aims. Kemp and P. W. Paget, who were to accompany him on the trip he planned to make, made all the arrangements and kept Marconi's name from the reporters who haunted the steamship offices. And when the three men slipped quietly aboard the S.S. *Sardinian* on November 25th, 1901, few recognized them and those few did not know the historical potentialities of this voyage.

It was not Cape Cod they were going to visit. It was Newfoundland in Canada, the point of land in the New World that is closest to the Old. Transatlantic communication was Marconi's goal, but he knew better than to attempt it immediately between Poldhu and the Cape, when Newfoundland and Poldhu were so much closer together.

The secrecy that surrounded the trip was not broken even when the *Sardinian* docked at St. John's, Newfoundland, on December 6th. As far as anyone knew, even after the news leaked out that Marconi had arrived, his intentions were to try to establish contact with wireless-equipped ships. It was a likely enough story, as many ships sailed close to that port on their way across the ocean; and in any case the Canadians were not particularly curious.

The spot finally chosen for their experiment was Signal Hill, a high point overlooking the harbor of St. John's. There, beside the Cabot Memorial Tower, erected in honor of an earlier pioneer into uncharted worlds, stood some old

military barracks. In one of them Marconi unpacked his numerous bulky boxes and trunks. Part of the unwieldy luggage proved to contain enormous balloons and kites, by means of which he hoped to raise an aerial wire. That method, the three men had decided, would be quicker and simpler than erecting an ordinary aerial. If there was little wind the balloons were to be used; if there were strong winds Marconi intended to fly kites.

In a drafty room heated by an old stove they prepared to install their coils, their batteries, the coherer and the other equipment they had brought across the ocean on a trip that had lasted many days—and with which they hoped to detect an electric wave that would flash across that same watery expanse in about 1/100th of a second.

CHAPTER ELEVEN

THREE DOTS ACROSS THE OCEAN

NEWFOUNDLAND IN midwinter is not a pleasant place. The gales that sweep in from the Atlantic lift up great waves of icy water and dash them to foam and spray on the rocks. The cold is incessant, and the damp that accompanies it soon penetrates the warmest clothing and the sturdiest bones.

On Monday, December 9th, three days after the party had arrived, the preliminary work was begun. Ground connections were driven into the stubborn frozen earth. They took turns at the job, working as rapidly as possible until the cold stiffened their fingers and their clothes had become uncomfortable strait-jackets, hardened by the rain that turned to ice as it fell. A working day consisted of a series of brief shifts outside, broken by dashes for the comparative warmth

of the barracks. A pot-bellied stove glowed red in there, and the windows were always steamy with the moisture that rose from the wet clothes spread close to the fire.

"The cold and damp was intense," Marconi said later of those difficult days, "and from the hour of our arrival the wind seemed to increase in strength. This did not worry me or my assistants, we had come prepared for such conditions, though naturally hoping for better ones. There was one thing to be thankful for, the transmission of signals would not be affected by the weather, but the continuous wind and rain made the task of erecting the necessary apparatus very difficult indeed. Progress had literally to be made by inches."

On Tuesday, the 10th, Marconi launched a kite as a test. It took all three of the men to hold the huge cloth contraption steady enough to get it up, and though it twisted and bucked in a heavy wind they managed to lift it and reel it safely in again.

The next day, Wednesday, was the date on which Poldhu had agreed to start its three-hour periods of transmission, beginning each day at noon. But the experience with the kite had not been very successful, so Marconi decided to try a balloon for this first attempt at reception. He hoped that an aerial suspended from it would hang steadier than one attached to a kite. Consequently a 14-foot balloon was inflated with about 1,000 cubic feet of hydrogen—enough to lift ten pounds of aerial wire—and the awkward object was sent aloft. But scarcely was it out of reach when the gale ripped it loose from its moorings and the men on the ground had to stand helplessly by while it floated off into the clouds. It was already so close to three o'clock that another attempt at raising an aerial that day was useless. Disappointed but

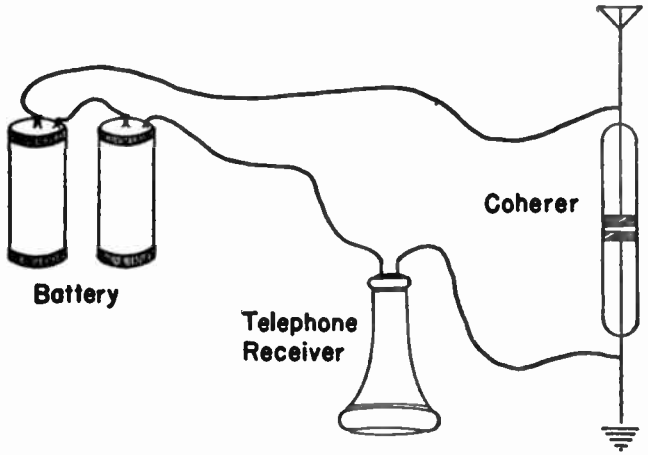
still determined, back the men turned to the barracks and the meager comfort of the red-hot stove.

Kemp, who always assumed responsibility for the physical welfare of his boss, lifted the steaming pot of hot cocoa that he kept constantly ready, and over the warming drinks they discussed plans. It was obvious that a balloon was out of the question. What about trying the kite again? Strangely enough, it was wireless' most recent advance—tuning—which would make the use of the kite so bad. Had they been able to raise a balloon with any success, it would have remained at a fairly constant level, and the aerial dropped from it would therefore have been of constant height and capacity. There were no wave meters at that time, but Fleming had calculated the length of the Poldhu wave at approximately 960 meters, or 3,000 feet; a balloon aerial could have been—at least roughly—tuned to that wave length. But it would obviously be impossible to tune a receiver correctly when its aerial was bobbing erratically up and down, as the kite to which it was attached dipped and rose in the windy upper air.

Kemp replenished the cocoa supply and still they talked. And finally Marconi decided to discard the recording apparatus which he had installed and use in its place a very delicate coherer connected with a telephone and a battery. Perhaps, even if it was not syntonized with Poldhu's wave, an untuned coherer could pick up the three dots of the Morse S—the prearranged signal which Poldhu was to send. This return to an earlier type of equipment would have its drawbacks—one in particular would be most regrettable—but it would, perhaps, be better than nothing.

Early on Thursday morning they got their cumbersome kite up into the air, where it looped and dove and righted

itself again some 400 feet above the earth. And then they returned to the barracks and settled themselves to watch the clock. The wind rose steadily. The tin roof over their heads rattled until it seemed as if the grim bare room were alive with noise.



CIRCUIT USED TO DETECT THE HISTORIC "S" AT NEWFOUNDLAND

As the hand approached the hour they all grew tense. One of the men passed Marconi a plate of bread and cheese, and he ate and drank his cocoa silently, his eyes fastened on that slowly creeping hand.

Finally he rose, put his plate and mug on the packing case that served them for a table, and walked across the room. With deliberate movements he lifted the telephone receiver and put it to his ear. The time had come.

The other two watched his intent but unreadable expression for several minutes. Well? Was the signal coming through? They could never guess at whether the news was good or bad—the boss's face didn't change.

And then Marconi turned to Kemp, holding out the receiver. "Can you hear anything?" he asked.

Kemp flattened his hand against one ear to shut out the noise of the storm, and cradled the receiver against the other. And after a long moment he said "Indeed I can, Distinctly."

"Yes. I heard it too." Now Marconi allowed himself to smile. Kemp and Paget, more excitable, took turns with him at the receiver, their elation mounting. Paget said he could hear nothing, but insisted that that was because he was slightly deaf—which both the others knew to be true—and he was more than willing to accept Marconi's and Kemp's word.

Yes, of course they heard them—the three dots. They didn't come through steadily. They came and stopped, came and stopped—for a whole hour that second time. And finally, at about half-past two, the shrieking wind flung the aerial up to its maximum height and the signals came through again for the last period of the test.

When Poldhu stopped sending at three o'clock the men sat down around the stove. Kemp and Paget were in a fever of excitement by this time. Was Marconi going to announce to the papers immediately that they had bridged the Atlantic?

But Marconi shook his head. He had heard the three dots of the S—heard them repeatedly. He had known he would. He had always been sure that he could make his electric vibrations span even those endless miles. But to state publicly that he had heard them? Oh, no. Because he had no tangible proof.

"But Kemp heard them too," Paget said warmly.

"Of course I did."

Marconi shook his head. If he could have used his recording receiver he would have unmistakable evidence now. He

would have his three dots clearly printed on a slender paper ribbon. But as it was—

Cyrus Field's great Atlantic cable emerged from the ocean depths near by. Hundreds of messages crossed on it every day from England to America and back again. But those messages were facts that could be proved. And comparison with them would make more ridiculous than ever any claim that depended for its credibility on the simple honesty of two men. Who would ever believe that Kemp and Marconi had heard anything at all?

No, it was not yet time to make an announcement. So the three men went down the hill to the town later that evening under a pledge of silence.

They were back on the hill the next morning, and up went the kite again. Once more the wind prevented it from maintaining a constant altitude, but huddled around the table full of instruments Marconi and Kemp heard the dots again. They were weaker this time but they were still audible.

Kemp beamed. "Well?" he said significantly, "two days is twice as much proof as one, isn't it?"

Marconi nodded. Yes, at least now he could be sure those evenly-spaced dots of the day before had been no accident. He had never suspected them of being anything but Poldhu's signal but, as Kemp said, two days was better proof than one.

Suddenly he capitulated. There were still no marks on paper tape to offer as evidence, but— It had been a grueling job and he had finished it to his own satisfaction and that of his assistants. Under the circumstances a whole day was an amazingly long time for a young man only 26 years old to keep a secret of that magnitude.

When they went down into St. John's that night Marconi

released a statement to the press. On December 15th, 1901, the New York *Times* printed:

WIRELESS SIGNALS ACROSS THE ATLANTIC

MARCONI SAYS HE HAS RECEIVED THEM FROM ENGLAND

St. John's, N.F., December 14—Guglielmo Marconi announced tonight the most wonderful scientific development of recent times. He stated that he had received electric signals across the Atlantic ocean from his station in Cornwall.

. . . Though satisfied of the genuineness of the signals and that he has succeeded in his attempts to establish communication across the Atlantic without the use of wires, he emphasizes the fact that the system is yet only in an embryonic stage . . .

Marconi was still being cautious—and so was the *Times*. The story was a modest one and they had been careful to print it as the statement of a claim, not as the reporting of a fact. "Marconi says . . ."

And "Marconi *says* . . . ," with a not-too-flattering emphasis on the verb, was the reaction of many readers, scientists and laymen alike.

"Are we supposed to believe him just because he *says* he heard them?"

"I feel the same way about it."

"I understand his assistant heard them too."

"Oh, well—his assistant. Of course he'd say so."

"If he got the signals why didn't he record them on a tape?"

"Sure—why didn't he? Maybe because he never got them at all."

The press and the public discussed it, asked their questions and, in many cases, provided their own answers. Marconi's

word alone was enough to satisfy some people, but not everyone was ready to believe.

Marconi tried to answer the complaint against a lack of recorded signals by explaining the difficulties they had encountered at Newfoundland, and the conditions which had prevented them from using a tuned recording receiver. But he realized that those who would not believe one thing he said, would not believe another. They would regard it as a lie told to bolster a lie—or an excuse that did not excuse dishonesty.

There was only one thing to do. He would have to establish a regular, permanent station at Newfoundland. On December 16th he left St. John's for Cape Spear, to choose a site where he could erect a 200-foot aerial pole. And on his return to St. John's the following day he was greeted by a startling announcement.

The Anglo-American Telegraph Company, owners and operators of the transatlantic cables that left the ocean in Newfoundland, had served him with papers. They contended that they possessed a monopoly of the telegraph business in Newfoundland, and that unless Marconi stopped his experiments they would take legal action against him and his company.

It was a severe blow to the immediate progress of Marconi's work. But strangely enough the action had beneficial results in other ways. If the cable company regarded Marconi as a menace, the public immediately reasoned—reversing its earlier judgment—there must be something in the young man's experiments after all. A big commercial organization would not be frightened by a claim which it believed to be untrue. Newspapers commented on the fact that the value of cable stocks and bonds had taken a sudden drop. Every-

where people gossiped of the undeclared war between the cable company and the young inventor and popular opinion, usually sympathetic toward any David who dared a Goliath's wrath, veered in Marconi's favor.

The cautious New York *Times* wrote editorially on December 19th:

> The more the incident of the proceedings of the Anglo-American Cable Company against Signor Marconi is considered, the more evident it becomes that the management of that company is in the hands of short-sighted, narrow-minded, unprogressive persons . . .
>
> Marconi could have been helped in no better way than by recognizing his system as a dangerous competitor before he had ventured to make that claim for it himself.

Investigation showed that the charter of the Anglo-American Company had only two more years to run. No wonder the company was alarmed at the vision of a future in which it might be dissolved altogether. And at that news indignation rose even higher. The New York officials of the organization were besieged by reporters but no one could be persuaded to make a statement until finally F. A. Bevan, the company's chairman, announced with a note of desperation that the communication to Marconi had been sent without his knowledge.

The people of Newfoundland recorded their opinion of the fuss by passing a resolution at their Council meeting of December 20th:

> The Council are much gratified at Signor Marconi's success, marking, as it does, the dawn of a new era in trans-oceanic telegraphy, and deplore the action of the Anglo-American Company.

Now Marconi could number his friends and supporters

by the thousands, but his attitude toward the excitement indicated that it was much ado about nothing. With characteristic quiet he had accepted the edict of the cable company and begun to make preparations for locating his permanent station elsewhere—preferably, he thought, in Nova Scotia.

Friendly hands reached out to help him. Alexander Graham Bell, inventor of the telephone, offered Marconi the use of his estate on Cape Breton. And the Canadian government, quick to realize the opportunity at hand, offered every possible aid. In response to an official invitation from them Marconi journeyed to Ottawa, where he was handsomely entertained while the whole problem was discussed. Cable rates at that time were about 25 cents per word, and government officials were much interested in the possibility of cheaper transatlantic communication. So it was finally decided that the Canadian government would supply £16,000 toward the sum required for building a station, if Marconi would promise that wireless telegraphy—when it was established—would offer rates not to exceed ten cents per word. Marconi agreed tentatively, subject to the approval of his own company officials in London.

It was further decided that the station would be erected at Glace Bay on the Cape Breton coast, about 16 miles from the city of Sydney. When Marconi left Ottawa he went to Montreal to confer with officials of the Canadian Pacific Railway about the use of the railway's telegraph lines for the re-transmission of messages received at Glace Bay. Plans were really beginning to take shape.

Marconi then went on south to Cape Cod. Vyvyan had completed the South Wellfleet station except for the aerial,

which had not been replaced after the great circular one had blown down. But now Marconi had another, more important job for Vyvyan to do, and asked him to get packed up for the trip back to England. Vyvyan was to be in charge of constructing the new Glace Bay station, and he should consequently be in London while it was being designed.

Once more Marconi was ready to go home, but New York could not let him leave until it had paid its respects—and very warm respects they were. At one of the most brilliant affairs the city's old Waldorf-Astoria Hotel had ever witnessed, the young man was honored by the American Institute of Electrical Engineers. Famous scientists traveled many miles to be present for the occasion, and those who could not come sent messages of congratulation.

The Institute's wizards had used their imagination and their talent to provide a setting suitable for the event. Strings of flashing electric lights were fashioned into coils of wire and sparks. The word "Poldhu" in lights emblazoned one end of the room, and "St. John's" the other, and between the two, small electric lights were strung to form series of the three dots for the historic letter S.

Charles Proteus Steinmetz, the immigrant boy who had become General Electric's proudly-hailed genius, presided as president of the Institute. Flanking him at the speakers' table were such notables as Professor Elihu Thompsor, Alexander Graham Bell—whom Marconi heartily thanked for his generous offer—and Dr. M. I. Pupin, professor of Electrical Mechanics at Columbia University. Marconi, usually so wary of social gatherings, knew that this was no meeting of excited hero-worshippers. Here was met some of the best minds in his own field, eager for what he could

tell them and able to understand what he was doing and what he intended to do.

Thomas A. Edison could not attend, but a message from him followed Steinmetz' address:

> I am sorry not to be present to pay my respects to Marconi. I would like to meet that young man who had the monumental audacity to attempt and succeed in jumping an electric wave across the Atlantic.

The toastmaster, T. C. Martin, editor of *The Electrical World*, said, "I was talking with Mr. Edison within the last ten days, and he said that he thought that some time there might be daily signals across the Atlantic without wires, but that he did not know when, and being preoccupied he did not think he would have time to do it himself." The audience laughed and Martin went on. "He said to me, 'Martin, I'm glad he did it. That fellow's work puts him in my class. It's a good thing we caught him young.' " And that time there were cheers intermingled with the laughter.

Finally Marconi rose to his feet, thanked his admirers for the honor they had paid him, and then spoke about his work. Knowing that most of the guests had followed his work fairly closely, he spoke chiefly about his most recent experiments—those with syntonic receivers—and mentioned the important new advance in ship wireless: transmitters and receivers on shipboard had all been tuned to the same wave length, so that an SOS could be picked up by any other ship in the vicinity.

He did not refer to the cable company by name, but the audience applauded happily when he said, "At present, by the existing cable system, the sending of messages across the seas is put out of the reach of people of moderate circumstances. The cost of laying the cables is so large that cable

companies have to charge a high price for the service. My system will cheapen the cost very greatly."

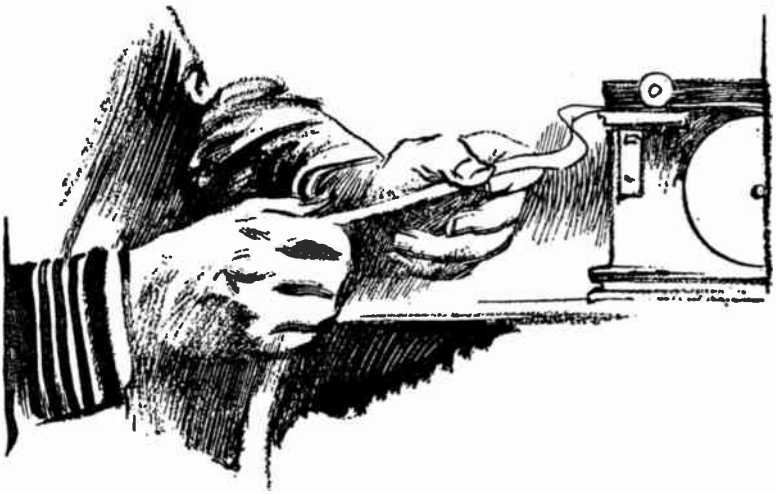
And then he concluded with a statement which, if heard aright, could clearly be understood as an answer to those still-persistent critics who maintained that Marconi was not an inventor at all, but only a thief of other's inventions: "I have built very largely on the work of others, and before concluding I would like to mention a few names. I may miss a few of them, but I would like to mention Clerk Maxwell, Lord Kelvin, Professor Henry and Professor Hertz. I do not know if you are aware that the message received at St. John's was heard through a telephone receiver and in connection with the telephone the name of Professor Alexander Graham Bell is inseparable."

To the men present, and indeed to men of science all over the world, these words were an honestly spoken appreciation of the debt Marconi owed his predecessors. Marconi had never claimed discovery of the electro-magnetic waves, nor invention of the coherer to detect them; he had merely claimed that his use of the waves and the detector was new, and that until his first simple transmitter and receiver had been put to work, no one had thought of using Hertzian waves to transmit letters.

But those honest and unassuming sentences could also be easily misinterpreted. There were many who understood them as a confession that Marconi had actually added nothing to the progress that culminated in wireless. And those same people, of course, doubted the fact of transatlantic messages. There would always be doubters and detractors, but Marconi had too much sense to worry himself unduly over what they thought.

He was conscious of it, however, and when the gala din-

ner was over and he was preparing to leave the United States, an idea was already buzzing in his head—an idea that would convince these sceptics of the truth of the statement he had issued from St. John's—convince them long before ground had even been broken for the Glace Bay station.



CHAPTER TWELVE

PROOF IN BLACK AND WHITE

MARCONI'S RAPIDITY of thought and action was often a source of wonderment to those who knew him only slightly, but the speed with which he hurried through a multitude of tasks early in 1902 must have left even his associates gasping for breath. On January 22nd he and Vyvyan left the United States on the S.S. *Philadelphia,* and back in England he settled down with furious energy to the many things he had to do. It was first of all necessary to report to his board of directors and obtain their approval of the tentative agreement he had worked out with the Canadian government. Then he had to get his staff started on the job of designing a transmitting station for Glace Bay. And finally he was faced with the necessity for gathering together concrete evidence of the actual possibility of transatlantic wireless.

None knew better than Marconi himself that his success at plucking the letter S out of the air at Newfoundland did not automatically foretell the success of regular trans-oceanic communication. He had proved that such communication was possible. Now he had to transform possibility into established fact. So while the board of directors carried on their series of meetings, and while the new station was taking shape on the drawing boards, Marconi was moving forward in his own mind with the first step in that job—plans for a better and more conclusive demonstration of long-distance wireless.

So quickly did his plans take shape that it was only one month from the day he had left New York when he boarded the *Philadelphia* again. The newspapers of February 22nd were too full of a sudden crop of calamities to take notice of his departure; storms were lashing the Atlantic and delaying the arrival of ships; catastrophic fires in New York City were being whipped to horrifying dimensions by the severe winds. The world, frantic with worry, had no time to remark on the activities of even one of its favorite sons. Marconi slipped aboard at Cherbourg at midnight, and few were aware of his identity or curious about the instruments that he and his assistants carried with them so carefully.

His party had reserved four staterooms, and they had been on board only long enough to get settled when they went to work. In one of the rooms they set up sensitive coherers and tuned coils and condensers, set to detect the wave from Poldhu and no other. There was a telegraph instrument too, for this time Marconi was going to secure visible evidence of his success. From the small cabin a lead wire ran up to the aerial stretched between the masts of the ship.

As the *Philadelphia* slipped out into the blackness Marconi and his staff readjusted the tuning to the new aerial, and soon messages began to crackle and spark their way up to that mast-held wire and across the channel to Poldhu. Communication was established without any difficulty. But since reception and transmission within a limit of 250 miles was no longer an astonishing feat, Marconi made no attempt to demonstrate his instruments to anyone outside his own circle for the first long hours of the voyage.

Soon, however, Cherbourg had been left almost 500 miles behind. Marconi took care that First Mate Marsden should be invited into the cabin, and as the time drew near for the regular prearranged transmission from Poldhu, he flicked the switch and watched the officer's face as the telegraph clicker began its jerky dance.

"Those are Morse code signals from Poldhu, in Cornwall," he said.

"From Poldhu! But they can't be."

Marconi smiled.

"I'm sorry," Marsden said quickly. "I didn't mean to— But we're almost 500 miles from there."

One of Marconi's staff laughed. "In that case the message must have needed almost 1/400th of a second to get here."

"But—" The First Mate swallowed. "You mean it, don't you?" he said suddenly. And at their cheerful nods he turned toward the door. "Just wait until the Captain hears about this." He left the cabin in a rush.

All over the ship he told his news, and was met with just such incredulity as he himself had first shown.

"From Cornwall? Nonsense!"

"But I saw them, I tell you."

"Sure you're feeling all right, old boy?"

When he returned to Marconi's quarters he was as disgruntled as only a newly-convinced man can be, when he has failed to make others believe the very thing he himself had doubted so short a time before.

Marconi smiled. "Don't worry about it. Poldhu is going to transmit regularly. Why don't you bring them all here tomorrow evening—the Captain and your brother officers. We'll see if we can't prove it for them."

"Tomorrow! But that will be too late. We'll be a thousand miles from Poldhu by then."

"I know. But I still think we'll receive their messages." And as Marsden continued to stare at him he added "I'm not in the least worried about it. Why should you be?"

The officer grinned weakly and departed.

The little cabin was crowded the following evening. Captain A. R. Mills and several of the other officers had come, but in all of their faces was a look of frank scepticism.

Marconi kept his eye on the clock. "We'll begin in a moment," he murmured. And when the hands crept closer to the second at which Poldhu was scheduled to begin, he released the mechanism that set the white tape moving.

At first nothing appeared on it, and the receiver was silent. The officers glanced at each other and nodded imperceptibly. Just as they had suspected—the thing was impossible.

"It should start—now." Marconi spoke the last word crisply and as he did so there sounded a click from the receiver, and the white tape instantly began to show its familiar pattern of dots and dashes.

" 'Fine here,' " Marconi translated calmly after a moment. And a little later he read again " 'Thanks for telegram. Hope all are still well. Good luck.' "

He glanced at his watch, saw that the transmitting period

had come to an end, and nodded with satisfaction as the clicking noises ceased.

"Well?" He looked at the faces of his guests.

"See? What did I tell you?" Marsden was as pleased as if he himself had been responsible for the feat.

"Amazing. Amazing, Mr. Marconi," the Captain murmured.

The other men joined enthusiastically in his opinion, and for a while the room was noisy with congratulations and eager questions.

"I'd be glad to sign that strip of tape," the Captain said finally. "If my name on it will be of any use to you—after all, I saw the signals being printed, and I'd be proud to endorse them."

The rest of the officers watched as Captain Mills and First Mate Marsden affixed their signatures to the slip. Marconi thanked them and put it carefully aside. This was what he needed. This was his proof—visible evidence of communication over a distance of 1,000 miles, that evidence signed and testified to by men of unquestionable integrity.

"There were people who said that my signals at St. John's were accidents—just atmospherics," he said. "I think I can prove to them that that wasn't so." He glanced at his watch again. "Let me show you something else. Poldhu is now resting for five minutes; then they will begin to broadcast again. Now, there are a good many ships equipped with wireless these days, and it's possible that one of them may be operating within range of this receiver. I want you to be convinced that we are tuned to Poldhu's wave length and can receive nothing else. I'll start this tape moving again, and we'll see if any other messages come in."

Slowly the few remaining minutes went by. The tape

slipped out of the machine with an even flow, but without a mark on its white surface. If a mark *were* to appear now, while Poldhu was, according to Marconi's own word, not sending, it would cast a heavy cloud of doubt over the accuracy of all messages so far received. It would mean that the St. John's signals too could, perhaps, have been "strays" from a passing ship.

There was one minute left . . . thirty seconds . . . fifteen seconds . . . And still the paper was unmarked and the silence unbroken. Ten seconds . . . five . . . Suddenly the receiver broke into a chatter and the inker began to set down its little tracks.

The confident smile that had never left Marconi's face relaxed a little. He had never doubted—but it was good to have his confidence verified.

Before the ship docked in New York Marconi had broken every previous record for long-distance wireless. His recorder had printed messages up to a distance of 1,500 miles, and with a telephone receiver he had received signals up to 2,099 miles.

A group of eager reporters met him at the pier, anxious to get what they had heard might be a fabulous story from the young man only recently heralded at the great Waldorf-Astoria dinner. Word had gone around that the miracle-maker had done it again. Marconi begged off from their questions until later in the day, and then he received them at his hotel. He had no hesitation whatsoever this time about giving a statement to the press—but actually no statement was necessary. All he had to do was to hand them the signed bits of tape and the chart of the trip as made out by Captain Mills:

MESSAGES RECEIVED ON BOARD STEAMSHIP PHILADELPHIA FROM MARCONI STATION AT POLDHU (CORNWALL) AS FOLLOWS: NO. 1—250.5 MILES; NO. 2—464.5 MILES; NO. 3—1032.3 MILES; NO. 4—1163.5 MILES; NO. 5—1551.5 MILES. SIGNALS 2,099 MILES FROM POLDHU WHEN WE WERE IN LATITUDE 42.01 N., AND LONGITUDE 47.23 W.

"The *Umbria*," he told the men, "is equipped with Marconi equipment and followed us all the way over, only a few hours behind. But her apparatus did not receive a single Poldhu signal—because, gentlemen, her receiver wasn't tuned for Poldhu. Ours was, and we heard every word that Poldhu transmitted. Furthermore, we heard nothing at all when Poldhu was silent."

"Weren't you surprised, Mr. Marconi," one of them asked, "to find that you could receive so far?"

"I knew the signals would come in up to 2,100 miles," he replied, "because I had fitted the instruments to work to that distance. If they had not come, I should have known that my operators at Poldhu were not doing their duty."

Man might make a mistake, but his machines—never.

That same belief in the infallibility of machines was expressed in a different way in one of the *McClure's* magazine articles that appeared shortly after the voyage of the *Philadelphia*. *McClure's* had kept its promise to its readers to inform them regularly of the work of this young Italian inventor.

> On board the *Philadelphia*, during the week of February 22nd, a receiver took and printed on a tape messages from Cornwall 1,551 miles away. Notice this statement. No telephone instrument was used; there was no human agency to "think" or "imagine" and perhaps err. At a prearranged hour a transmitter at Cornwall shot a message through the air;

> Marconi and the ship's officers and others on board the *Philadelphia* heard the tick, and, looking at the tape, saw the dots and dashes which you or I or anybody still can see. When a machine does a thing, we humans believe; so long as a man stands between, we doubt.

Yes, this time they believed. This time they could not say "But are we supposed to believe him just because he *says* he heard them?"

The trip had done more than establish the long-distance record. For one thing, it seemed to prove that the curvature of the earth—a bugaboo long held up as the final and unsurmountable barrier to wireless over any great distance—did not impede the wireless waves. That was heartening news. But it also seemed to prove something else: that the range of wireless was drastically shortened by the effect of daylight. The 1,551-mile record had been made at night. During the daytime no message had been received after the ship was farther than 700 miles from England.

If Marconi had known of this strange aspect of the electric waves' behavior, his experiments in Newfoundland might have been more successful. All his tests there had been made in daylight. Probably, had he tried to pick up the Poldhu S at night, even Paget's deafness would not have prevented him from hearing.

Once more the answer to a problem seemed to be: more power. Marconi was determined to see that his Glace Bay station had enough power to send its waves across the ocean whether it was day or night. With this thought firmly in mind he left New York for Ottawa to discuss in further detail the new Canadian station. Vyvyan had been appointed managing engineer of the Marconi Company in Canada, and given full responsibility for building the new plant. It was

to be even larger than Poldhu—it was to be a 50,000-watt station.

Vyvyan enthusiastically agreed. He had as much faith in power as Marconi did. And, as things turned out, he gave "G.M.," as the boss was called by his fellow-engineers, even more power than he had asked for. Vyvyan's only opportunity of getting the kind of alternator he wanted was to have one built to order for him; it would be a long process and he was impatient at the delay, but there seemed nothing else to do. And then, unexpectedly, he got the chance to buy second-hand a 75,000-watt alternator. He had no objection at all to the additional power, and it was a great saving in time. Work really began in earnest at the grim headland on Glace Bay. The site chosen for the station was directly over one of the large coal mines that dotted the region, and it was therefore possible to hire temporarily idle miners to aid in the construction. The mixture of nationalities working at the new station was almost as varied as the tongues in which its transmitter would eventually send out messages.

When Marconi returned to England once more he had two particular jobs to do: he wanted to do some research on the reason for bad daylight reception; and he wanted to perfect a new type of detector which he had been thinking of for some time.

The coherer he was using at the time—good as it was—was not hardy enough for ship installations. The vibration and tossing of a ship often shook the grains out of adjustment, and much time was lost while it was restored to working order. Marconi wanted a detector that would remain constantly receptive, regardless of jarring and of weather.

He set to work and finally evolved a new type of instrument utilizing a moving wire belt that traveled beneath

two horseshoe magnets. Vibration or jarring had no effect on the new detector and it seemed to be sensitive enough to detect the faint electric waves.

Shortly after he patented what he called his magnetic detector, Marconi was offered the use of an Italian battleship, the *Carlo Alberto*, for a series of tests. The ship would make it possible for him to study his new device in operation, make further efforts to unravel the mystery of daylight reception, and try long-distance communication with the improved Poldhu transmitter. Marconi accepted happily.

All through the summer of 1902 he cruised on her, accompanied for part of the time by the new Italian king, Victor Emmanuel III—another reason why Marconi found the trip pleasurable. His old feeling for royalty still remained with him, and this particular voyage offered him unusual opportunities for basking in the approval of rulers. The first destination of the *Carlo Alberto* was Kronstadt, the famous old fortress in the Gulf of Finland, where Victor Emmanuel was to meet the Czar of Russia.

Anchor was dropped at Kronstadt in the morning, and Marconi immediately took advantage of the chance to attempt communication with Poldhu, so many land-and-sea miles away. Unfortunately even the new Poldhu transmitter was not powerful enough to overcome the effects of daylight on electric waves traveling that distance, but by nightfall the signals came through with great strength. Their first Russian visitor, Admiral Makaroff, was suitably impressed.

The next morning the Russian imperial yacht, *Alexandria*, dropped anchor near by and Nicholas II, emperor of Russia, came aboard the *Carlo Alberto* to greet the Italian king and to inspect Marconi's apparatus. Reception from Poldhu during the daylight hours of the imperial visit was impossible,

but Nicholas expressed great interest in the messages that had been received during the night, and gave concrete expression to his admiration for Marconi by sending an emissary to the ship with a medal for him the following day.

The *Alberto* then turned around and headed for the coast of Sweden, continuing from there to Kiel. Kaiser Wilhelm II of Germany was aboard his own yacht in Kiel harbor, but he did not come aboard the Italian ship—and Marconi was apparently glad enough to avoid this particular emperor. His feeling toward the German royal house was dictated by his experiences with the German patent office, dating back to the earliest days of the Post Office experiments in England. The German Professor Slaby had been one of the observers of these tests, and he had at the time admitted publicly that Marconi had done what no man had previously done; his admiration for the Italian's work had actually been printed over his name in a magazine article. But upon his return to Germany Slaby had patented a wireless system of his own. The German patent office had accepted Marconi's patent some time before, and this fact would ordinarily have served as a barrier to further patents in the same field. But since, in this case, the patent office apparently recognized no barrier at all, it was generally believed that both the office and Slaby had been acting on royal command. It was little wonder that Marconi's admiration for royalty admitted an exception in this particular case.

And there had been, more recently, an additional reason for his sense of animosity. Suggestions had been steadily emanating from Germany to the effect that Marconi's wireless waves would be blocked by any really huge masses of rock, such as Gibraltar. Consequently when the *Alberto* headed south from Kiel excitement on the ship began to rise.

Spanish telegraphists boarded the ship at Ferrol, in northwest Spain, and expressed amazement and admiration at the sight of the Poldhu signals being printed on the paper tape. But their congratulations were scarcely noticed amid the general tension. The *Alberto* slipped along the Spanish coast and finally came to rest near the towering rock that guards the entrance to the Mediterranean. Now the German claims would be answered.

But all through the first evening not a signal came through. As the night wore on Marconi remained steadfastly at his post, and the entire crew, their loyalty aroused to fever pitch, stayed awake so that they might not miss the glorious moment of success when it arrived. But would it arrive? Was it possible that the Germans had been right?

Admiral Mirabello of the *Alberto*, fierce in his admiration for Marconi, boiled with rage. It could not be wireless that was at fault. It could not be his good young friend. Those Germans must somehow have played some trick—and they must not be allowed to get away with it.

And then, at 3:15 in the morning, a flash came through. It happened to be a news bulletin announcing the illness of the Empress of Russia. They had all been entertained cordially in Russia only a little while before, but in spite of that fact the sensations of all those on board was one of tremendous relief. They were very sorry indeed for the Empress, but they assumed she would recover. And who could tell if wireless would have been able to sustain the blow, had Gibraltar proved a wall the waves could not hurdle?

After that triumphal occasion the *Alberto* continued southward, along the coast of Africa, drawing each day farther and farther from Poldhu. Night reception was gen-

erally good, but nothing that Marconi could do seemed to increase the 500 miles that was the limit for getting signals during the day. The *Carlo Alberto* finally headed back toward Italy, and Marconi went on wrestling unsuccessfully with his problem. It was, although he could not realize it, a problem that was to remain unsolved for some time.

When the cruise was over word came in October that the Glace Bay station was ready to be tested, and with a new surge of enthusiasm Marconi headed the *Carlo Alberto* away from the warm blue Mediterranean toward the bleak shores of Canada. The good Admiral Mirabello, who had received orders that he was not to accompany the *Alberto* on this new voyage, embraced Marconi when they said goodby, murmuring "You never liked my strong cigars—but that was a detail. I have no family, but now that I know you I feel that I have a son." And he made a sad little ceremony of presenting to Marconi the Italian flag which had been his pride while he commanded the *Alberto*.

"I shall fly it on the most prominent tower of the world's largest wireless station," Marconi promised.

It was a promise he kept. And each time that he saw the flag proudly battling the winds at Glace Bay he remembered with affection the man who had given it to him and the joys and trials they had shared on that memorable trip.

CHAPTER THIRTEEN

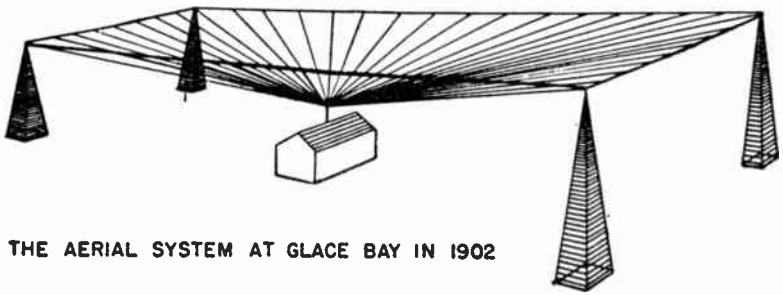
"NO SIGNAL RECEIVED"

MARCONI WAS 28 years old when he arrived at Glace Bay aboard the *Carlo Alberto* to begin his attempts at transatlantic communication. For several years—indeed, since that fateful day in the Biellese mountains—he had been consistently successful in his efforts to put to use the electric waves which Hertz had discovered. First a few yards, then a few miles, and finally across the Atlantic, his transmitters had sent the electro-magnetic impulses. There had been minor obstacles, but none that his will and ingenuity could not master within a short time. It seemed to the world as if he had but to wave his hand to cause miracles.

The crossing on the Italian warship had been an exceedingly rough one, and might have been interpreted as an indication of fortune's change of mind. But Marconi, accustomed to success, was his usual unassuming but confident self as he and Vyvyan inspected the largest wireless station that had yet been built.

There was a new type of aerial at Glace Bay—a duplicate of one that had been built at Poldhu a short time before. Four wooden lattice-work towers reared their height 210

feet into the winter air. From a distance it looked as if someone had turned a gigantic table legs up. Cables connected the tops of the towers, forming a square from which hung hundreds of wires that were gathered together directly over the roof of the transmitting building placed in the square's center. Off to one side, out from underneath the aerial, were the buildings that housed the boilers, the steam engines, the



THE AERIAL SYSTEM AT GLACE BAY IN 1902

huge alternating current generator and the transformers. All looked shipshape and ready to work.

Marconi didn't waste any time, once he was convinced that all was in order. He had arrived on October 31st, and he made his first attempt to pick up Poldhu the next day, November 1st. The results were anything but encouraging. Poldhu, when it did come in, was so weak and erratic that the signals were unintelligible.

The arrangement of wires on the aerial was changed, and another attempt was made, again without success.

"Polhu's a big station, but it's not big enough," Marconi said finally. "Power, Vyvyan. That's what we need—more power. I'm sure that if we had enough drive behind those waves they'd get through all right."

"That means a new transmitter at Poldhu," Vyvyan pointed out.

"Yes, I suppose it does—eventually," Marconi nodded. "But there's something else we can try first. We can reverse our procedure: transmit from here, and let Poldhu do the receiving. After all, we've got 75,000 watts on this side and—"

But Vyvyan had already jumped to his feet, ready to get to work. Smiling, Marconi went after him.

On November 19th Glace Bay set its high-voltage current crashing across a spark gap. But Poldhu reported nothing received.

For nine days in the bitter cold of the Canadian winter the men slaved on the aerial and other pieces of equipment, and for nine nights they stayed at the key trying time after time to get a signal through. Finally, on November 28th, Poldhu reported reception, but added that the signals had been too weak to be readable.

Marconi sat in the gray dawn, his head in his hands, his brow creased with concentration. "Seventy-five thousand watts and still no—" Suddenly he lifted his head. "Maybe there's too much aerial here. Maybe all those wires interfere with each other." He got up to find Vyvyan and when their conference was concluded they fell into bed for a few hours' sleep. In the morning they would unhook three whole sides of the aerial square, and try using only one.

It was several nights later that they were ready for the new test. The spark jumped and the windows rattled. But Poldhu reported no reception.

"We'll try a bigger spark," Marconi said doggedly, and the next time they sent a blue flame almost as thick around as a water glass leaping across the gap.

On December 5th it seemed as if perhaps their luck had turned. They sent out a two-hour program of signals, and

during that period Poldhu received weak signals for the first half hour, nothing at all for the next 45 minutes, and good recordable signals for the last three-quarters of an hour.

"We've done it, boss," one of the men said jubilantly. "It looks as if we've finally found the proper arrangement. Doesn't it?" he added, more soberly, as Marconi stood staring at the transmitter.

"I hope so, but—" The younger man shook his head. "We have to be sure that each time we send a letter here, they'll pick it up in Poldhu. And—well, we can scarcely say we've achieved that yet."

"I know. But this is the first time we've tried this system. Just wait until tomorrow night."

But on the following night Marconi's warnings proved justified. With exactly the same arrangement of equipment they had previously used, they failed to send a single signal across the ocean. And the night after that was just as bad.

"We seem to be working utterly in the dark," Vyvyan said wearily, rubbing a grimy hand across his eyes. Sleepless nights and work-filled days were beginning to have visible effect on the men. Neither Vyvyan nor Marconi had lost their faith, but they were too realistic not to admit to discouragement. "What works one night fails the next," he went on. "And we never have any way of knowing whether the fault lies in our equipment or in bad atmospheric conditions between here and England."

Marconi smiled bleakly. "It's our fault—whichever it is," he said. "If the trouble is caused by air conditions we can't control, we've got to find a way to make apparatus that will overcome them. And we've got to do it soon. Soon." His fist emphasized the last word by pounding the table.

Marconi's vehemence was caused by more than ordinary

impatience, or an inventor's natural eagerness to see his apparatus successfully doing its job. He was being goaded from several directions, chiefly by his London office. More and more urgently the communications from there stressed the necessity of establishing a transatlantic service quickly—as if the directors thought they could hurry matters by strong language. They pointed out that bidders for the stocks and bonds of the Marconi Wireless Telegraph Company were not so numerous or so eager as they had been. Marconi must restore their flagging faith—and immediately.

The newspapers of the world were likewise beginning to grumble and mutter. Maybe people had been right to doubt that young man after all. Even a ship captain's signature on a piece of paper would not command their respect for ever, if it were not followed reasonably soon by further concrete evidence of success.

"Marconi *says* he can transmit across the ocean. Why doesn't he do it then?"

Finally, on December 14th, luck smiled on Marconi once more. Poldhu reported having received an entire two hours of signals clearly and readably. It was the first completely successful transmission they had accomplished, but Marconi could wait no longer. Undependable as he feared it still was, the transatlantic system was announced as ready for service.

George Parkin, correspondent for the London *Times* and a professor at Upper Canada College, was invited to witness the first public attempt to send a message across the ocean. He had also been invited to prepare that message.

At one o'clock on the morning of the 15th he joined the tense and expectant Marconi staff in the transmitting building. Several officers of the *Carlo Alberto*, still at anchor near Glace Bay, were also present.

Marconi seated himself at the long-handled telegraph key. "Cover your ears," he cautioned.

For a little more than a minute the room was filled by the blue light of the sparks, and then, as the switch was pulled, the silence settled down again heavily. They all waited, their eyes on the recording instrument that was to transcribe Poldhu's signal that the system was working; but it remained motionless. Finally Marconi picked up the telephone headset, fastened the earpieces snugly, and took up a pencil. After a second his eyes narrowed and he began to write down the letters as he heard them.

No signal received.

Without a word he turned back to the key once more, the visitors covered their ears, and again the rapid succession of blue flames lighted the room. But again there was the same discouraging answer. With inexhaustible patience Marconi kept at it, over and over, sending out his signals time after time, pausing only to listen to the weak signal coming in from Poldhu with its message of repeated failure.

At three in the morning he got stiffly to his feet. "Let's call it a night, gentlemen," he said calmly. "At six this evening we may have better luck."

But they didn't. They tried for an hour, without success. At ten in the evening they tried again. Parkin's message was battered and creased by now, from the numerous times he had hopefully unfolded it as Marconi settled himself before the key, and then folded it up again when it was obvious that no signals could get through.

At a little after midnight Marconi said with a thin smile, "If at first you don't succeed—" and sat down once more. The sparks flashed as the signals went out, tossing Parkin's message once more into the air.

And then back came the message they had been waiting for throughout all those long hours. Poldhu reported

READABLE SIGNALS THROUGHOUT

Parkin's message—the first transatlantic press dispatch—read:

TIMES, LONDON: BEING PRESENT AT TRANSMISSION IN MARCONI'S CANADIAN STATION HAVE HONOUR SEND THROUGH TIMES INVENTOR'S FIRST WIRELESS TRANSATLANTIC MESSAGE OF GREETING TO ENGLAND AND ITALY—PARKIN.

But the *Times* correspondent's troubles were by no means over. His message had been sent, but he had bargained without Marconi's attitude toward royalty. Marconi had given orders to Poldhu that no message was to be relayed out of the Cornwall station until messages to the rulers of Italy and England had been delivered.

He settled himself now to transmit those messages. But the electric waves showed their disregard for kings. It was as if Parkin's message had tired them out, and no thoughts of history in the making could revive them. On the 17th Marconi tried again, and during the transmission period the generator developed a defect which made it necessary to shut the station down for a day. On the evening of the 18th transmission was resumed, but reception was so bad that only part of the signals were understandable.

It was another three days before Poldhu actually received the royal greetings and sent them on their way. And not until then did Marconi release Parkin's message to the *Times*.

Poor Parkin! Now he was to meet another blow—but this one he could not blame on either Marconi or wireless, although it was to do neither any good. The reporter had agreed to write stories about the first wireless transmission

across the Atlantic for both the London *Times* and the New York *Times*. He left Glace Bay immediately after his message had been transmitted and, on the train to New York, wrote out the duplicate accounts. By a previous arrangement between the two papers, they had agreed to publish the story simultaneously—which meant that the New York *Times* would wait until the London paper had received its copy by mail.

Parkin rushed the story destined for London to the first boat leaving New York, and the staff of the New York *Times* put their copy in type and waited impatiently for word from London. They were ready to print at a moment's notice when London informed them to go ahead. But no such message arrived. A frantic cable elicited the information that London had never received its copy at all. More anxious days went by, and finally there was delivered to the New York *Times* a battered, smudged envelope—the very one Parkin had mailed weeks before—returned for insufficient postage. Parkin had mistakenly underpaid the amount, by five cents. And although the letter had reached the London *Times*, the mail reception office of that paper was operated on a strict rule: all underpaid mail was refused. While the editor clamored heatedly in his upstairs quarters, the obedient clerks had shipped the letter back without making the slightest attempt to learn its contents. They were following orders, but it is unlikely that their employer appreciated their strict adherence to his edicts on that particular day.

Finally the story was printed. Newspapers all over the world had already published announcements of Marconi's success, but Parkin's account was eagerly read despite that fact, as the first eye-witness report of what took place that cold winter night at Glace Bay.

A little after midnight our whole party sat down to a light supper. Behind the cheerful table talk of the young men on the staff, one could feel the tension of an unusual anxiety, as the moment approached for which they had worked, and to which they had looked forward so long. It was about ten minutes to one when we left the cottage to proceed to the operating room. I believe I was the first outsider allowed to inspect the building and machinery.

It was a beautiful night—the moon shone brightly on the snow-covered ground. A wind, which all day had driven heavy breakers on the shore, had died away. The air was cold and clear. All the conditions seemed favorable.

Inside the building, and among its somewhat complicated appliances, the untechnical observer's first impression was that he was among men who understood their work. The machinery was carefully inspected, some adjustments made, and various orders carried out with trained alertness. All put cotton wool in their ears to lessen the force of the electric concussion, which was not unlike the successive explosions of a Maxim gun. As the current was one of most dangerous strength those not engaged in the operations were assigned to places free from risk.

It had been agreed that at the last moment before transmission, I should make some verbal change in the message agreed upon, for the purpose of identification. This was now done and the message thus changed was handed to the inventor, who placed it on the table where his eye could follow it readily. A brief order for the lights over the battery to be put out, another for the current to be turned on, and the operating work began.

I was struck by the instant change from nervousness to complete confidence which passed over Mr. Marconi's face the moment his hand was on the transmitting apparatus—in this case, a long, wooden lever or key.

He explained that it would first be necessary to transmit the letter "S" in order to fix the attention of the operators at Poldhu, and enable them to adjust their instruments. This

continued for a minute or more and then, with one hand on the paper from which he read and with the other on the instrument, the inventor began to send across the Atlantic a continuous sentence.

Outside there was no sign, of course, on the transverse wire from which the electric wave was projected of what was going on, but inside the operating room the words seemed to be spelled out in short flashes of lightning. It was done slowly, since there was no wish on this occasion to test speed. But as it was done, one remembered with a feeling of awe, what he had been told—that only the ninetieth part of a second elapses from the moment when he sees the flash till the time when the record is made at Poldhu. . . .

The first west-east message had been sent across the Atlantic. What that means to mankind no one can even guess. . . .

The story may have been fine journalism but it was, unfortunately for Marconi's future peace of mind, bad reporting. Parkin had avoided any mention of the hours of fruitless efforts that preceded the final successful transmission of the wireless. Readers believed that transatlantic communication was now as simple and easy as pressing a telegraph key, while in reality wireless was still almost useless because of its unreliability.

The world eagerly forwarded messages to Glace Bay for transmission to Poldhu, and the London office of the company made it quite clear that to refuse to accept them would be admission of failure. So, although none knew better than Marconi how erratic his wireless was, and in spite of the fact that he would have preferred to shut the station down entirely so that he might spend all his time improving the equipment, he was forced to divide his efforts between the commercial and research aspects of his work. This necessity must have seriously delayed perfected transatlantic transmis-

sion, but there seemed to be no alternative. The staff at Glace Bay spent its nights trying to get messages through to Poldhu, and its days experimenting with new circuits and new aerials. Vyvyan refers to this trying period in his book, *Wireless Over Thirty Years:*

> . . . From a technical point of view it appeared advisable to refuse to send any more messages, and to devote the time entirely to experimental work, but the publication of the success of the transmission of these messages had attracted world-wide attention to Marconi's work, and it was thought impolitic therefore not to send messages through. The nights were therefore spent in sending messages and the days in trying out various modifications of circuits or apparatus. During the period from the transmission of the first message on 15th December up to 20th January, thirty-eight messages were sent with varying results, some were repeated twenty-four times before they were received, whereas others were repeated six times and received correctly on each occasion.

One of those messages referred to an event in Vyvyan's own life—the birth of his daughter. A wireless was sent to the *Times* for inclusion in the column of birth announcements, but unhappily it was not among those that "were repeated six times and received correctly on each occasion." The message as sent read:

> JAN. 3RD WIFE OF R. N. VYVYAN, CHIEF ENGINEER MARCONI'S CANADIAN STATION, OF A DAUGHTER.

But atmospherics played tricks with the first syllable, and the printed notice referred gravely to the young mother as "Jane, third wife of R. N. Vyvyan."

In the midst of this troublesome period Marconi had to leave Glace Bay. News had arrived that the Cape Cod transmitter had been completed, and on January 14th Marconi

departed to inspect it. Station CC, as it was called in its early days, was to be an important link in his transatlantic system; it was planned that messages originating in the United States would be sent into the air there, picked up by Glace Bay, and relayed from there to Poldhu.

Cape Cod is a narrow stretch of land completely exposed to the Atlantic's fury, and the station itself stood on a tall sand dune facing the roaring water. It could be reached only by walking from the town of South Wellfleet, through a small woods and across a sandy expanse—not a pleasant tramp in bitter, blustery weather—but Marconi by that time was well accustomed to wind and rain and cold.

As soon as his fingers were thawed out he settled down to work, and after a few days' testing he decided to attempt transmission of a message from President Theodore Roosevelt to King Edward VII of England. Between nine and eleven at night—usually good hours for the wireless—the words were tapped out:

HIS MAJESTY, EDWARD II, LONDON, ENGLAND
IN TAKING ADVANTAGE OF THE WONDERFUL TRIUMPH OF SCIENTIFIC RESEARCH AND INGENUITY WHICH HAS BEEN ACHIEVED IN PERFECTING A SYSTEM OF WIRELESS TELEGRAPHY, I EXTEND ON BEHALF OF THE AMERICAN PEOPLE MOST CORDIAL GREETINGS AND GOOD WISHES TO YOU AND ALL THE PEOPLE OF THE BRITISH EMPIRE.

THEODORE ROOSEVELT
SOUTH WELLFLEET, MASS., JAN. 19, 1903

Glace Bay picked it up without any trouble and repeated it for Poldhu between 11 o'clock and midnight.

And then Marconi learned that the waves had been tricking him again. This time it was a cheerful trick, but it was none the less evidence of the unpredictable quality of the elements

he must learn to predict and control. He heard that Poldhu had picked up the President's message direct from the Cape, and sent it on to London long before the Glace Bay signals had come through. The United States and England had been linked by wireless—but the link had been forged accidentally; and Marconi knew better than anyone else that he could not promise the regular repetition of that happy accident.

He stayed on at the Cape for a few more days, and when he left he announced that all three of the transatlantic stations would be closed for about two months. A great deal more work would have to be done before he could honestly offer his system to the public as a dependable means of communication.

CHAPTER FOURTEEN

THE WAVES GROW LONGER

On January 22nd, 1903, Marconi sailed for home and Bologna greeted her famous son with wild enthusiasm. Young Guglielmo—he was still only 28—had traveled with kings and miraculously signaled across oceans during the years since he had lived in the Villa Grifone. His native city was eager to honor him.

At a public reception which crowded the Littoriale Gymnasium to the doors, public officials and scientists—including his old friend, Professor Righi—outdid one another in their efforts to make complimentary speeches worthy of a man whom the whole world knew and admired. Annie and Giuseppi Marconi smiled at one another over the head of their remarkable child; a short time ago he had made toys in the attic; now he was making history.

Perhaps Marconi accepted all this as his due. But perhaps, when he blushed and stumbled through his reply to their congratulations, it was because he really wanted to say, "No,

you mustn't do this. You don't understand. I haven't yet accomplished what you think I have." Transatlantic communication was not to be an actual fact for many long months, but neither he nor the admiring crowd could know just how much trouble lay ahead. In any case, whatever the reason for his blushes and his choking voice that night, they served to make his fellow-citizens love him more. They proved to the men and women who had known him as a child that their hero was still so unspoiled by fame, still so shy, that the applause of his own neighbors could transform him into a red-faced stammerer.

Rome honored him too, during that trip, and it was a much-feted young man who finally settled down to his work in England. Slightly improved equipment was installed at Poldhu, and on March 20th the stations were reopened for further tests. England's reception of the Glace Bay signals was so successful for several days that Marconi was prevailed upon to start a press service for the London *Times*. Regular bulletins were transmitted for publication under the heading "By Marconi Wireless"—until, toward the middle of April, reception faltered again. Suddenly a heavy coating of ice formed on Glace Bay's aerial, owing to a spring thaw, and the entire complicated network of wires crashed to the ground.

Marconi refused to accept any further commercial assignments throughout the remainder of the spring and the summer that followed. Vyvyan had devised a means of sending a warming electric current through the aerial wires to melt any ice that formed—a system subsequently adopted wherever aerials were subject to such a calamity—but the next months were steadfastly devoted to experimentation. Marconi had no intention of once more undertaking a job he

couldn't finish. And the irresponsible behavior of the air waves during that period confirmed his opinion that trans-atlantic communication was still not trustworthy.

But during that summer he undertook an exhaustive study of the work of the British physicist, Oliver Heaviside, and the American professor, Arthur Kennelly. Heaviside had in 1900 announced the theory that there existed, a great distance above the earth—100 miles or so—an ionized layer composed of atmospheric particles electrified by the action of the sun. Electric waves entered this stratum, it was claimed, were partially absorbed by it, and were then bent back toward the earth. And because this layer was closer to the earth during the daylight hours, owing to the action of the sun's ultra-violet rays, a greater proportion of the electric waves would be lost in it during the daytime.

For the first time Marconi knew the reason why it had been possible for his waves to travel great distances in spite of the curvature of the earth. And he also had his first hint as to why his transmission had always been poorest during the daytime. Now perhaps he could figure out a method for solving one of his most serious problems.

A comparison of his electric waves to the sound of a fog-horn suggested the solution. The lowest notes of the horn—that is, the sounds made by low vibrations, or long wave lengths—travel the farthest through the deadening atmosphere of a heavy fog. Perhaps longer wireless waves would be equally successful at fighting their way through what had come to be known as the Heaviside-Kennelly layer.

There was still no such instrument as a wave meter, but calculations indicated that Poldhu and Glace Bay were using waves approximately 2,000 meters long. Convinced now that this length was inadequate, Marconi set about to increase it.

It would have been a simple process for present-day engineers, but in 1903 it involved a redesigning of almost his entire apparatus—a money-consuming, time-consuming job, and one that Marconi had to approach with caution. He couldn't immediately double or triple his 2,000-meter wave length, but he enlarged it somewhat by erecting a larger aerial at Poldhu—an enormous umbrella-shaped contraption composed of thousands of feet of wire.

When that was done he set sail for the United States again, having arranged with both Poldhu and Glace Bay to transmit to his ship, the Cunarder *Lucania*, throughout the voyage. His reception was good—1,700 miles at night and 1,000 miles during the day. The latter distance—the best daytime distance he had yet achieved—pleased him particularly. That trip was also satisfactory for three other reasons: it was the first time a ship had received messages from both sides of the Atlantic simultaneously; the fact that the reception from Glace Bay was as good as that from Poldhu proved that wireless waves traveled as easily from west to east as from east to west—a matter many scientists had been doubtful about; and the first shipboard newspaper, the *Cunard Bulletin*, was printed as a result of Marconi's constant reception of news from shore.

Altogether he arrived in New York in fine spirits. Reporters clamored for information about his plans, but he put them off with his usual skill. One thing he was particularly careful to keep from them was the fact that he intended to see Edison while he was in the country. An Edison-Marconi conference would have been enthusiastically attended by all news men who heard of it, and as it happened they would have been much interested in this meeting—but not because of its significance for the scientific world.

Edison lived and worked in a large old rambling house in Orange, New Jersey, some 40 minutes from New York. He had invited Marconi to visit him whenever he could, and it was on a Sunday morning that the young Italian decided to go. He looked up the trains, found one that suited him, and slipped out of his hotel past the waiting reporters. With him was the youthful Marchese Luigi Solari, a lieutenant specially assigned to assist Marconi during the *Carlo Alberto* cruise, and since attached to his staff. It was a pleasant day and they walked from the Orange station through the quiet streets to the inventor's house.

But for a long time there was no answer to their ring, and Solari was beginning to feel that they might well have made more formal plans for their visit when the door suddenly opened. It was the 56-year-old Edison himself who greeted them, wearing the clothes he always referred to as his "working outfit."

"Come in, come in. Sorry I kept you waiting—I was in my workshop. This is a fine surprise." And talking happily he led them through a silent house to his own laboratory.

The two guests looked vaguely about for their hostess and finally asked for her.

"Away. She's away. Going to be sorry she missed you too. But—now here, let's get comfortable. We've got the whole day to talk. This is great."

Soon he and Marconi were deep in the discussion of a new plan they hoped would cut in half the power then needed for transmission. Solari listened politely for a while, trying to adjust himself to the general air of informality, but his mind began to wander. Suddenly he realized that there was only one thing that interested him—food. He glanced at his watch. No wonder! It was 1:30, they had had an early

breakfast, and that walk from the station had whetted his appetite.

He coughed once or twice, trying to catch his chief's attention. Marconi had spent more time in the United States than he had himself; perhaps he knew at what hour they could reasonably expect to be served lunch.

But Marconi seemed far too absorbed to notice anything. It required judicious management for Solari to move casually around until he stood behind Edison, and, out of the famous man's sight, send messages in sign language to Marconi about his sad plight. Finally Marconi saw him. And to Solari's delight he nodded slightly to show he understood and then—during an instant when Edison had turned his head—signaled back that he too was starving.

Edison chatted on, scarcely pausing for breath, and it was well past two o'clock before Marconi could insert into the conversation his carefully-worded query. "How do you manage about your meals, Edison?" he asked. "When you're out here working, I mean. And when Mrs. Edison is away."

"Eh? Oh, on Sundays I don't bother much. Generally let the servants go out, as a matter of fact. Makes the house quieter, you know. And I can always manage with a sandwich or something."

Solari's heart sank into his boots and even Marconi looked a little pale. And then suddenly Edison added "You've had your lunch, of course?"

"Well, as a matter of fact—we—you see, the train left at—"

"Oh, good gracious." Edison got to his feet hastily. "Here we've been talking away and it's—why, it's long after two, isn't it? You must be starved. Come on."

Solari's eyes brightened with hope but a moment later they saddened again.

"Don't know quite what we could eat, though," Edison had said, pausing in his tracks. "The maids won't be back until night. I suppose you couldn't wait until— No, you're hungry. Well—"

His brilliant mind seemed so unable to cope with the situation that Solari would have laughed if he had not been so personally concerned in the problem.

But fortunately the second inventor present was able to offer a constructive suggestion. "We might just look in the kitchen," he said. "Anything at all would do, you know. I don't mean to—but—"

"Of course. Of course. Capital idea. Come on."

Cheese, bread and biscuits was all they found, and it was Solari himself who had to assume the difficult technical task of tea-making. Still, it was better than nothing. And when they returned to New York that night he found Marconi as willing as he was to put off all their other tasks until they had had a good dinner.

Marconi was in the United States only for a short time, but he arranged for the enlargement of the Glace Bay aerial, and then hurried off to Cape Cod to prepare that station for a new series of tests. When Glace Bay was ready they attempted communication between the two stations and finally, on September 26th—after Vyvyan had rewound the transmitting coils at the Glace Bay station to increase the inductance—faint readable signals were exchanged during the daylight hours.

Marconi returned to England shortly afterward, but left behind him instructions for doubling the power at Glace Bay. This meant, of course, dismantling the 75,000-watt outfit. Before Vyvyan did so he tried adding more inductance to the aerial circuit, and managed to get much better

daytime signals through to the Cape—further proof that longer waves was what they needed.

It was the end of May in the following year—1904—before Vyvyan finished reassembling his new transmitter, powered by an alternating current generator with an output of 150,000 watts. Once more Marconi sailed—on the *Campania* this time—to test it and the new transmitter at Poldhu. Disheartened by the recent death of his father, he found little in the results of the new trials to cheer him. By doubling his power he had succeeded in adding just 200 miles to his daylight range—and that was not enough.

Wireless was the wonder of the World's Fair at St. Louis that summer—but to Marconi it was still a failure because he was not yet ready to offer dependable transatlantic communication. In his discouragement he decided to concentrate upon one of his earlier plans—ship-to-shore messages. He was sure that by using Glace Bay, Cape Cod and Poldhu, a Marconi-equipped ship could keep in constant touch with at least one shore station. And so it proved. In fact, matters proceeded so successfully that the Cunard Company contracted for a regular news and information service—at the rate of £10 daily for each 100 words a ship received. The resulting revenue assumed considerable proportions. More and more ships were equipped with wireless apparatus, and ocean travelers came to expect their daily newspapers on shipboard.

Cheered once more by this demonstration of the financial worth of his system, Marconi ventured to spend more time and money on a revived pursuit of longer waves. He decided that his aerials were still not large enough, and instructed Vyvyan to build a new circular one at Glace Bay; its diameter was to be 3,000 feet. Vyvyan reported that there was

not room on their chilly little headland for such an enormous piece of equipment, but added calmly that he would immediately search for and purchase a new site.

He found a location some six miles away, and during the bitter winter of 1904—when the temperature was often below zero—Vyvyan superintended the moving and the erection of the new aerial. By May 1905 it was ready for testing.

Once more Marconi set out for the New World. But this was more than a trip of inspection. It was a honeymoon as well. On March 16th, at St. George's Church in Hanover Square, London, he had followed his father's example and married an Irish wife—the Honorable Beatrice O'Brien, daughter of Lord Inchquin. It was not to prove a happy marriage, but neither Marconi nor his bride knew that then. Marconi was a proud young husband about to show off his latest achievement.

The Signora Marconi must have found the new aerial an imposing sight—even if she understood no more about it than Marconi's mother had understood of her son's first little coils of wire and handmade coherers. Fifty-foot masts—lower and better braced than those in the first fatal circular aerial—were arranged around the original four towers of the Glace Bay aerial; the transmission shack in the center was dwarfed by the network of 200 wires that surrounded it. Surely, this time, they could create and transmit a wave long enough to cross the ocean in daylight.

As usual, there was only one way to find out. His inspection over, Marconi tuned the plant carefully and set out on the *Campania* once more. Daylight reception on shipboard was good up to 1,800 miles—a 600-mile improvement over their previous figure but still, Marconi knew, not enough.

From England he sent word to Vyvyan to increase the wave length again, to about 3,600 meters.

Vyvyan soon replied that he was ready for tests. And one June morning, while daylight covered the entire Atlantic from shore to shore, he clicked off a series of signals. Tensely he waited. And the answer flashed back: Poldhu had received its first readable daytime message from Glace Bay.

It was a triumph that Marconi badly needed just then. About three and a half years had passed since he made that first rash statement to the press at St. John's; and two and a half years had passed since he transmitted Parkin's message to the London *Times*. His company and the public too had grown dubious of his eventual success. Some of the people who had once loudly repeated their scathing "Marconi *says*—" had ceased to talk about him altogether; regular transatlantic communication was, in some circles, not even considered enough of a possibility to be joked about and commented on.

It would have been satisfying to announce this most recent achievement, but Marconi had learned his lesson. He was certain now that he could safely undertake a public transatlantic wireless system, but he decided not to mention the fact until he had worked further on the two new ideas he had just had.

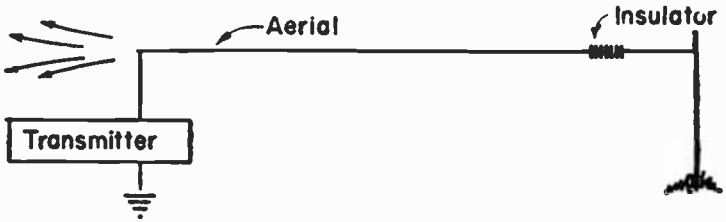
One stemmed from his dissatisfaction with the spark as a generator of electric waves. It wasn't consistent. If he tried to adjust his transmitter to a wave length of, for example, 3,000 meters, he found that the erratic spark would shift its speed of generation so that the resulting wave length might vary as much as 300 meters. Thus it was impossible for him to utilize syntony to its fullest efficiency; a receiver which he

knew how to tune sharply must instead be tuned broadly, so that it might accommodate itself to the varying wave lengths of the transmitter. He desired a new type of spark generator which could be depended upon to maintain a more constant wave length.

The second idea which was chasing itself through his mind had to do with aerial construction. It wasn't that he couldn't make an aerial long enough for long waves—that was fairly simple; all he had to do was add more wire to the many thousands of feet already strung in circles around his stations. But when he did so, and succeeded thereby in achieving a longer wave, it seemed to him that the efficiency of his station decreased considerably. Apparently something happened to the electric impulses as they raced around that cage of wire; it was as if the shape of the aerial confused and weakened them even before they left it. And there was one more thing that bothered this efficient inventor: he didn't like to think of his electric waves being sent out in all directions from a transmitter. After all, he reasoned, if a station in England is specifically designed to communicate with one in Canada, no purpose is served by sending out waves to lose themselves over Scotland, Europe, the North Sea and the Atlantic, in order that a portion of them may find their way to Glace Bay. He didn't think he could direct all his waves toward a single point by any reflecting device, but he hoped he could somehow cut down the waste of indiscriminate transmission.

He decided to tackle the aerial problem first, and immediately set to work on a small scale to determine which type would give him the best directional qualities for transmission. His initial step was to get rid of the cage-like effect of the aerials he was then using. It had struck him that the waves might find it far easier to leave an aerial that was stretched

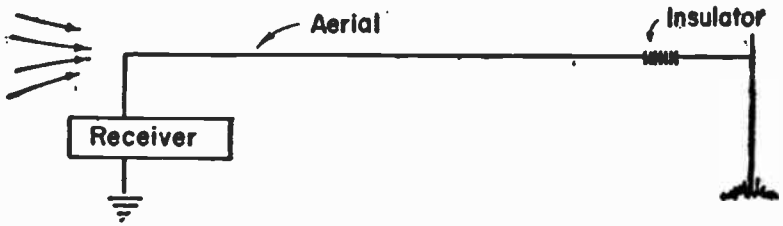
out in a straight line. So the apparatus he constructed consisted of one 200-foot wire about ten feet above the ground; one end of it was connected to his spark transmitter, the other end to a short pole. Tests proved to him that, with



DIRECTIONAL TRANSMITTING AERIAL

this new arrangement, the transmitter continued to radiate signals in every direction, but sent them most strongly in the direction opposite to that in which the aerial pointed.

Then it occurred to him that this idea might be as applicable to a receiver as to a transmitter. Consequently he set up a receiving set with a similar aerial, except that in this case he



DIRECTIONAL RECEIVING AERIAL

left the end opposite the coherer free to be shifted. And once more tests proved he had been right: signals came in with noticeably increased strength when his new aerial was pointed away from the transmitter to which it was tuned.

Naturally he was most anxious to show this new idea to his engineers, but before he could get them together for a demonstration an entirely new use for wireless occurred to

him. And with characteristic Marconi showmanship he decided to kill two birds with one stone—demonstrate his new directional aerial and illustrate his new utilization of wireless waves simultaneously.

"What's G.M. up to now. do you know?" The curiosity of the engineering staff as they met at the hour Marconi had appointed was obvious.

"Haven't any idea. Doesn't look very dramatic—but you never can tell with him."

No, it didn't look as if he could have anything very special to show them. They were familiar with all the apparatus he had set up, and the only unusual thing about it was its simplicity. If that single wire was an aerial, it was much the simplest aerial any of them had used for some time. There was one odd thing about it, though; one end of it seemed unconnected to anything except a loose support, and Marconi had stationed a man out there. But perhaps his duty was simply to keep it steady.

When all was ready Marconi tuned his receiver to the wave length used by all ships at that period, and picked up the telephone receiver. He asked each of them to hold it to his ear in turn. One by one they stared at him as they strained their ears. Not a signal was audible.

With a quiet twinkle Marconi stepped outside and waved his arm toward the man at the far end of the aerial. And to the surprise of the staff the assistant picked up the pole to which the wire was attached and began to walk with it.

Marconi handed the receiver around again. And suddenly the engineer who was holding it to his ear said "Wait a minute. Think I heard something."

Marconi waved to the distant assistant and he stood still.

Yes, they all heard the clicks now. But when Marconi sig-

naled once more to the bearer of the pole and he continued his slow journey the clicks faded away again.

Back and forth he walked, and with increasing mystification the engineers listened to clicks that faded and disappeared and became audible again. Marconi himself then took the receiver and when the clicks had mounted to their loudest intensity he said quietly, "Gentlemen, right out there somewhere—in just that direction—is a ship." His hand gestured to a spot on the horizon exactly opposite to that in which the aerial was now pointing.

Politely the men turned to stare out the window.

"You've got sharp eyes, sir. I can't see a thing."

"I can't see it either," the inventor answered. "But somewhere out there—right in a line with this aerial—is a wireless-equipped vessel. It's her signals we've been hearing."

They looked their puzzlement. After all, the boss was usually right, but what he was saying seemed a little far-fetched. It could very likely be true, of course, but how could he *know* it? And he sounded as if he knew.

"This aerial gets its strongest signals when it's in this position," Marconi went on calmly. "So a ship must be out there somewhere."

"But, sir—" One of the younger engineers started to speak and then fell silent. Nothing in his experience led him to believe that Marconi could be right, but still one didn't contradict the boss.

"Wait," Marconi smiled. "Just wait a while."

The minutes passed slowly and still the signals came in. The ship was talking to a shore station.

And then the young engineer said, his ear to the receiver, "I'm sorry, sir, but I think they're getting weaker." He

wished it hadn't been his luck to be listening when the boss was proved mistaken.

But Marconi only smiled again. "That's right. They would. The ship isn't standing still, of course, so the aerial is no longer exactly in line with it." Once more he motioned to the man patiently holding the aerial's far end and the man swung the wire over to a new position. As he walked the signals regained their strength.

"There they are again. Why, they're even louder than they were before!"

"Yes. The ship must be approaching the shore." Marconi took a pair of field glasses from the table and looked out over the water, judging the direction of his sight by the aerial.

"Look over there," he said with a grin, handing the glasses to the young engineer.

"Why—there *is* a ship! I can just barely see it—its mast is beginning to come over the horizon. And it's—it's exactly in line with the aerial."

"I told you it would be."

They gathered around him now with excitement. The boss really had something new and important, and they could all visualize its far-reaching influence. It was indeed a big day in the history of wireless: it was the beginning of the wireless direction finder that was to save hundreds of lives at sea.

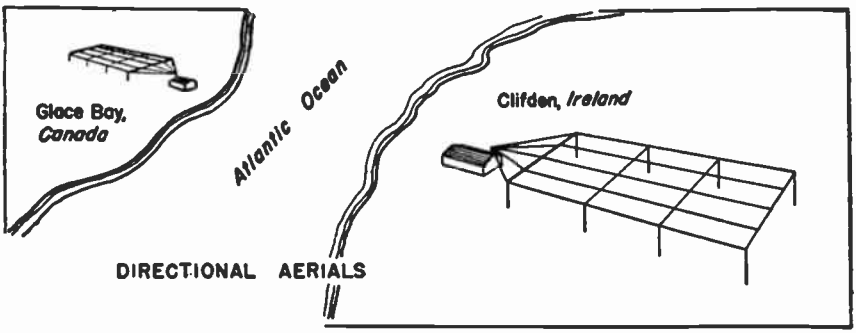
Many years later—in a speech before the Royal Society in 1937—Fleming spoke of that development with admiration, relaxing the usual terse quality of his technical speech to pay tribute to the particular quality of Marconi's mind which enabled him to conceive revolutionary ideas and translate them into facts.

> . . . Marconi was able to locate very closely the direction of a ship 16 miles away by shifting around the horizontal part

of the aerial in various directions and noting when the received signals were strongest.

This discovery illustrates very well Marconi's remarkable power of intuitive invention. He did not arrive at any of his results by mathematical prediction. In fact I think his mathematical knowledge was not very great. In the case of this bent antenna the theory of it was only worked out by me nearly a year later in a paper sent to the Royal Society.

Direction of the great part of an aerial's energy would mean, Marconi felt sure, that great distances would no longer be an insurmountable obstacle—either by night or by day. Furthermore, his straight aerial seemed to offer very little resistance to the electric waves. Immediately he made plans to change the systems at both Poldhu and Glace Bay, and decided that while he was about it he might as well increase the power of each one to 300,000 watts. Poldhu offered no room for a straight aerial of the size he needed, but that was no problem; Marconi simply bought a new site at Clifden in Ireland, and began work on a completely new station there.



While workmen were erecting the buildings at Clifden, and preparing sturdy supports for the long straight aerials to be set up there, Marconi returned to the problem of his spark generator. Finally he evolved what was known as the

rotary spark: a device permitting his spark to jump from the copper knobs rimming the edge of a large rotating disc, to the two smaller, more slowly rotating discs set close by. By turning the large disc at a constant speed, he was able to achieve a more consistent wave length. And—what proved to be more important—the new apparatus gave off a musical note which, unlike the old crackling noise, could easily be distinguished from the sound of static; signals were therefore far more understandable.

In September 1907 Marconi made another trip to Canada—a trip he embarked on with high hopes. He was so sure this time that he would be able to establish transatlantic communication that he permitted the rates to be set; in an agreement with the Canadian government—an agreement that had first been suggested after the tantalizing flash of success at St. John's—it was settled that his company's charges would be ten cents per word for the general public, and five cents per word for the press.

Test signals began to flash back and forth between Marconi at the new Glace Bay station and W. S. Entwhistle, the engineer in charge of the Clifden transmitter. Gone now was the crackle and crash of the old days; the humming of the new spinning disc seemed to set the building quivering with its intensity. A 1907 station looked and sounded very differently than its earlier sisters.

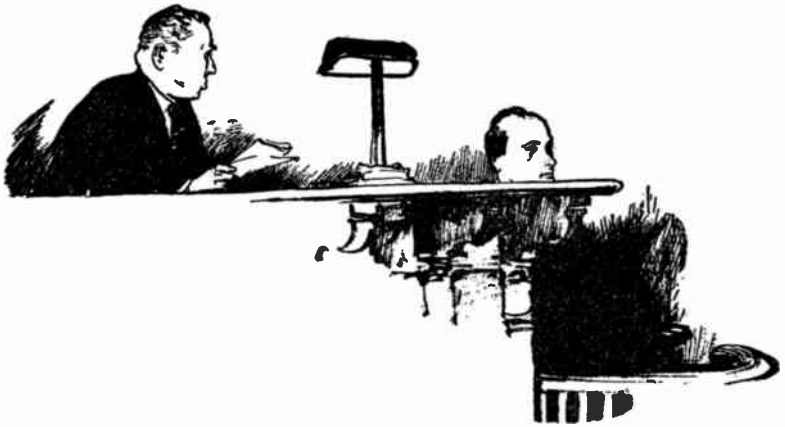
On October 17th activity at Glace Bay and Clifden reached a fever peak. Early in the morning Marconi sent the first official message winging across to Clifden—and Clifden reported perfect reception. And at 11:39 o'clock in Ireland, Entwhistle handed his operator a sheaf of messages to be sent out in the other direction. The Privy Councillor Lord Avebury was wirelessing the New York *Times:*

I TRUST THAT THE INTRODUCTION OF WIRELESS WILL MORE CLOSELY UNITE THE PEOPLE OF THE UNITED STATES AND GREAT BRITAIN, WHO SEEM TO FORM ONE NATION, THOUGH UNDER TWO GOVERNMENTS, AND WHOSE INTERESTS ARE REALLY IDENTICAL.

All day long the messages flew thick and fast. Scientists, public figures, newspaper editors—all of them wished to have their part in the historic occasion. Marconi himself sent a message to Lord Kelvin, and Kelvin replied.

It was a long day but it was a proud one. Late that night Marconi said, "I am entirely satisfied. Everything worked splendidly. We are going to operate a limited service for a while, but we have already handled from 5,000 to 10,000 words on account of it being a special day. . . . We are just quietly starting to do a regular business between Europe and America."

The six long struggling years were over. Transatlantic communication was at last a fact.



CHAPTER FIFTEEN

NEW DEVICES FOR OLD

In the twelve years that had passed since the first Salisbury Plain experiments, Marconi's timetable of progress had been an imposing one in spite of the long-delayed success of transatlantic communication. In 1897 he had signaled a distance of nine miles; in 1899 his clicks crossed the 30-mile-wide channel to France; in 1901 he picked up the historic "S" at Newfoundland over 1,800 miles of ocean; in 1905 he succeeded, at least temporarily, in establishing contact between Poldhu and Cape Cod, almost 3,000 miles apart; and in 1907 he had finally established a regular transatlantic system between Clifden and Glace Bay.

Now the whole scene of wireless was changing. For some time it had been increasingly invaded by other experimenters, and once the principles of long-wave, high-power transmission had been laid down the door was thrown wide open to a surge of new men and new ideas. It was not long before hundreds of improvements and refinements were added, and

other names took their places beside Marconi's. Wireless was no longer a dream in the mind of a young Italian; it was a recognized industry, the limits of which were beginning to stretch to world-wide dimensions.

In Germany, as has previously been mentioned, Professor Slaby had taken out patents for a method of wireless communication; out of these and others filed by fellow-Germans the *Telefunken* system had been evolved. And the fierce rivalry that existed between it and the Marconi Company on occasion broke through the boundaries of scientific competition into open quarrels. One of the earlier examples occurred when Prince Heinrich, brother of Kaiser Wilhelm, while en route to New York from Hamburg, sent a wireless message to a Marconi shore station and ordered the operator there to relay it to Berlin. The operator, fully aware of the feeling between the two companies, asked if the ship were in need of assistance, and added that unless it were he was under no obligation even to accept the message. The Prince reported this incident to his brother and the Kaiser, jealous of the growing importance of England and Italy in the wireless field, immediately called an international wireless conference in Berlin. Its announced purpose was the establishment of international regulations controlling wireless communications.

This conference, in 1903, soon developed into an attack by the German scientists on what they called the Marconi monopoly. They tried to persuade all shore stations to accept and relay all messages, regardless of their source. The Marconi Company's understandable objection to this was based on the fact that unless it could refuse to accept messages from ships equipped with other than its own apparatus, a ship

owner could install any kind of transmitter and still make use of the expensive Marconi shore stations.

Scientific sessions degenerated into free-for-alls. Germany claimed that its system was much superior to Marconi's, and that Slaby owed nothing to his early opportunities to observe Marconi's experiments. But the weakness of the arguments was evident: some German shipping companies had, after a trial of *Telefunken* equipment, replaced it with Marconi-built apparatus; and there still existed, for anyone to read, the article that Slaby had written for the *Century* magazine in 1898, paying tribute to Marconi for the originality of his work.

Final results were negligible. The conference served chiefly to illustrate Germany's desire to break England's hold on the wireless field, and her inability to do so. Several years afterward, following the Glace Bay-Clifden success, Marconi was the guest of the King of Italy at the Quirinal in Rome. Kaiser Wilhelm was also present, and during dinner one night the talk naturally turned to wireless.

"Signor Marconi," the German ruler said suddenly, leaning over the table, "you must not think I have any animosity against yourself, but the policy of your company I object to."

Marconi faced him squarely. "Your Imperial Majesty," he said in a clear voice, "I should be overwhelmed if I thought you had any personal animosity against myself, but the policy of my company is decided by myself."

Marconi could never feel very kindly toward German inventors—a not unnatural attitude by no means extended to other experimenters in his field. He was always interested in the contributions made by the growing numbers of inde-

pendent workers, and generous in praise of their authors. Frequently he purchased the patents owned by these other men, thereby furthering the interests of his own company and raising the general level of wireless communication as well.

Among the inventors whose work Marconi utilized was William Duddell, an Englishman, who discovered in 1900 that a carbon arc—such as was then used for lighting purposes—gave off waves of very constant frequency. In 1903 Valdemar Poulson improved this generator by operating it within a closed chamber full of hydrogen, coal gas or alcohol vapor; under such conditions the arc could be made to generate high-frequency oscillations excellent for wireless transmission. Eventually the arc transmitter replaced even Marconi's rotary spark in a great many of the important stations of the world.

In America, in 1901, Professor Reginald Fessenden applied for a patent for a system of wireless telephony utilizing a high-frequency alternating-current generator to create a constant wave. The idea of such a generator did not originate with him; Elihu Thompson in 1899 and later the brilliant Jugoslavian-born American, Nikola Tesla, had done experimental work with similar apparatus; and Fessenden's was a crude system. But out of it came the beginnings of voice transmission which in turn became radio as it is known today.

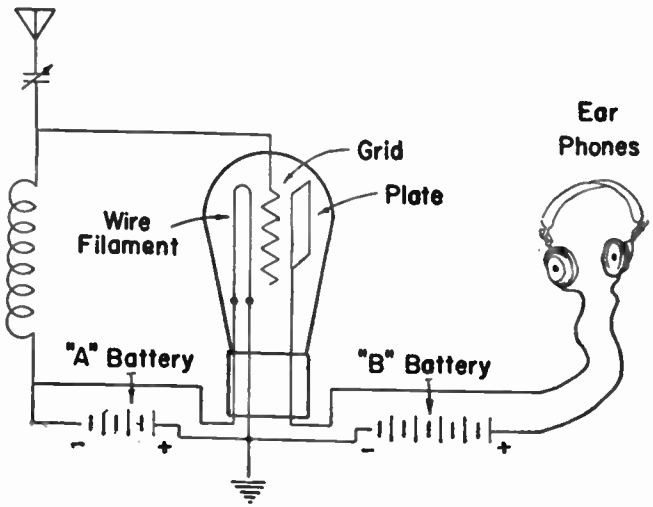
In 1904 occurred the invention that probably accomplished more for wireless progress than any other development since Marconi's own first transmitting apparatus. Fleming, of the Marconi staff, was searching for a better detector than the magnetic one then in general use, and he recalled a strange phenomenon discovered by Edison nearly two decades earlier. Edison had found evidence to indicate that

a stream of current flowed from the heated filament of an electric bulb. In order to catch this flow he inserted a plate in the glass bulb near the filament, but not connected to it, and discovered that a galvanometer showed current passing between this plate and the positive terminal of the battery used to light the bulb; the current passed only when the filament was glowing. Edison had made no effort to utilize this discovery, but he patented it under the name "Edison Effect."

Fleming took up where Edison had left off. He found that the current so mysteriously leaping from the hot filament to the plate was being conveyed on a path of electrons, and that it would travel in that one direction only, never reversing itself. Immediately he saw that the device could be used as a detector of wireless waves: the one-way passage of current would convert oscillating electric waves—which were after all only high-frequency alternating currents—into pulsations of direct current which an ordinary telephone receiver could detect. His experimental models worked successfully. He had discovered a new and better detector. And because the bulb served as a control, he called it a "valve"—the name still used in England for what is known in the United States as a vacuum tube.

Scarcely two years later the American engineer, Lee de Forest, added to Fleming's two elements—the filament and the plate—a third, the grid. This grill-like contrivance was so placed that the electrons leaping from the hot filament to the plate were forced to pass through it. If the grid were energized by wireless wave impulses from an aerial it would, he discovered, cause the electronic flow passing through it to oscillate at exactly the same frequency as the incoming wireless waves. Thus, de Forest figured, he could increase his electronic flow by using a battery, and obtain a substantial

battery current oscillating as fast as radio waves, but much stronger than the original waves. He had made the tube an instrument of amplification as well as one of detection. Owing to its high cost, and to the inefficiency of the early designs, the vacuum tube was not adopted for wireless use



A TUBE USED TO AMPLIFY RADIO SIGNALS

as rapidly as might have been expected. Furthermore, there were discovered at about the same time other detectors that were very inexpensive and worked very well.

Most prominent among these—and surely most familiar to Americans—was the galena crystal, discovered by G. W. Pickard. A few turns of wire around a cardboard cylinder, a piece of galena, and a pair of headphones constituted the majority of the early amateur receiving sets. But galena, popular as it became, had one serious drawback: it was difficult to keep adjusted. Shipboard vibration frequently was enough to break the contact once it had been established. Fortunately

Major H. C. Dunwoody of the United States Army soon discovered that carborundum pressed firmly against charcoal also acted as an excellent detector, and one that was not easily jarred out of position. Before long it had replaced the Marconi magnetic detector in a great many installations.

Professor Fessenden startled the world in 1906 by so improving his wireless telephony system that he succeeded in transmitting voice about 200 miles, between Brant Rock, Massachusetts, and Jamaica, Long Island. Not only was the voice quality good, but quite by accident the distance covered later proved to have been many times the 200 miles Fessenden claimed. Wireless operators in Scotland picked up the message, copied down what they had overheard, and sent it to the United States.

In that same year, 1906, E. Bellini and A. Tossi, Italian inventors, utilizing Marconi's principles of directed waves, developed a crude direction finder. Marconi and his staff were working on a similar device and in 1912 they bought the Bellini-Tossi patents to incorporate in their system.

Marconi's own research, after Clifden and Glace Bay were well-established, was directed toward world-wide wireless communication, which he still hoped to achieve by the long-wave system. Stations were springing up all over the world. Canada was talking of a series of land stations linking all the sections of that vast country from the Atlantic to the Pacific, and transmitters and receivers were being set up in Japan, China and the great continent of Africa. Soon, he hoped, all these would be in communication with each other and with the stations in Europe and the United States.

In 1910 he planned a trip aboard the *Principessa Mafalda*, urged by three considerations: convinced that he could guar-

antee England a wireless link with every one of her possessions, he wished to demonstrate exceptionally long-range transmission in order to persuade the British government of the feasibility of his plan; secondly, he wanted to check the possibility of transmission to South America, so far untouched by wireless; and, thirdly, because he was first, last and always a scientist, he couldn't resist the opportunities such a voyage would offer for new experimentation. The unknown had a perpetual fascination for him.

"Every success which I or my assistants had," he once remarked, "always taught us something, sometimes a great deal. We also found there was even more to learn than we anticipated; in science the solving of one problem so often means that there are two new ones awaiting solution."

On shipboard were installed the latest improvements in receiving apparatus—Fleming valve detectors and the most recently-developed tuning circuits. According to Captain H. J. Round, another engineer on Marconi's ever-growing staff and a member of the traveling laboratory:

> It was the most fascinating journey I ever had with him. We flew kites from the ship whenever the wind would allow us, usually up to a height of 6,000 feet, but the losses in kites were rather serious. Launching a kite from a ship is no easy matter. I remember once spending nearly two hours trying to get one up when the wind was unfavorable and finally giving it up. G.M. (for that was what we called Marconi among ourselves) came along presently and suggested that he should try his luck, remarking that some people did not know how to do it. Much to everyone's surprise he launched the kite with ease, and it was some time before I discovered he had arranged with the skipper to alter the course of the ship sufficiently to give a launching wind.

In spite of the difficulty with the kites, however, there was little or no difficulty experienced in maintaining contact with Clifden and Glace Bay. During the daytime a range of 4,000 miles was the record, and during the night Marconi picked up signals at a distance of 6,700 miles. Daylight reception was no longer a bugaboo; by the use of long enough waves—the waves then in use exceeded 10,000 meters—it could be managed with ease.

Marconi was enthusiastically received in Buenos Aires, and his success there had an immediate reaction on Uruguay, the little country directly across the River Plate from the Argentine capital. Interest in wireless was high in that progressive nation, and before Marconi left South America he had signed a contract for the erection of a high-power station at Punta Arenas. In a year or so it was in operation and a new distance record was made—from Uruguay to Liverpool, 7,300 miles.

Back in England once more Marconi was unfortunately not able to devote all his time to experimentation. Law suits against various companies which were infringing on his patents took much of his energy for a period. The first action of this kind, against the British Radio Telegraph and Telephone Company, hinged on Marconi's tuning patent, No. 7777, and was settled in 1911 in favor of the Marconi company. Not many months later he brought suit in the United States against the United Wireless Company and the Clyde Steamship Company. Again the famous "four sevens" was the point at issue, and again Marconi was vindicated. This victory almost doubled his company's business, resulting as it did in the transference to the American branch of the Marconi company of about 500 ship installations and

some 70 land installations, all previously operated by the United Wireless organization.

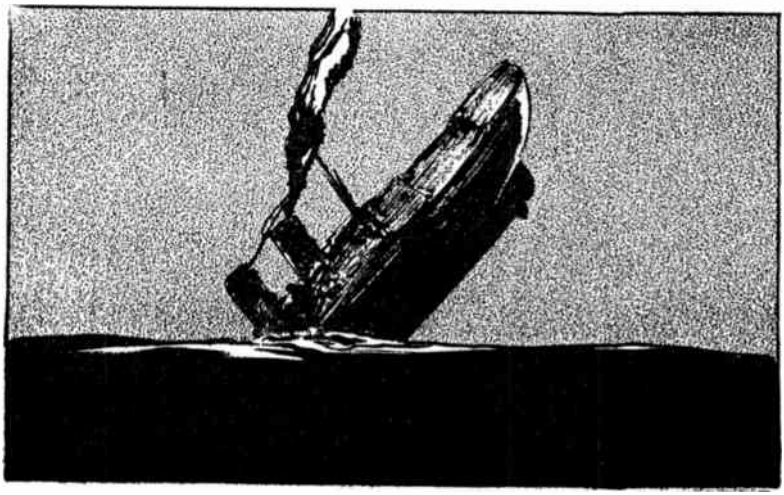
Another matter kept him from his laboratory on many occasions, but it was one to which Marconi was willing to give much of himself. Safety for ships at sea had long been one of his foremost goals, and a great proportion of his work had been directed toward the perfection of instruments designed with it in mind. But good equipment was not, he discovered, enough. It had to be used; and it had to be used wisely. Consequently he worked tirelessly toward the establishment of universal distress signals. And—an even more difficult task—he did his best to have laws passed compelling ships to install wireless equipment and man it constantly with competent operators.

He was by no means entirely successful. Shipping companies balked at the expense and their influence was a powerful one. Laws were finally passed making it mandatory for passenger ships of a certain size to carry wireless equipment, but the law did not insist that operators remain on duty at all times.

Marconi had done all he could to put his invention to work for the men who sail the treacherous sea. He could not thrust it upon the shipping companies if they were willing to trust sailors and passengers, ships and cargo to find their way safely across an ocean without the voice of the wireless to send warnings in time of danger, and summon help when it was needed. And then he received aid, as he had previously in the past, from the sea itself. When the installation on the *East Goodwin Lightship* had been instrumental in saving lives, the attendant publicity greatly hastened the use of wireless on similar ships and at lighthouses. Now a series of

sea disasters called attention once more to the beneficent work the mysterious electric waves could accomplish.

Shipwreck was a potent argument. Men on wireless-equipped ships were rescued by the faint miraculous clickings; other men died because ship owners had refused to take Marconi's advice—but they and their broken ships rose out of the depths again to succeed where Marconi had failed.



CHAPTER SIXTEEN

SOS–SOS–SOS

DURING THE fog-shrouded night of January 23rd, 1909, the S.S. *Republic*—a luxury liner bound for the sunny Mediterranean—nosed its way out of New York harbor. Several hours later, as she was moving slowly through the mist, her helmsman saw a gray mass looming up before him. He spun the wheel frantically and signaled for reversed engines, but it was too late to save the great ship from the trick the fog had played on her. A moment later she was rammed by the bow of the S.S. *Florida*. Steel plates screamed as they were wrenched out of shape, and the rush and roar of water told the terrifying story of flooded holds.

John R. Binns, the young English wireless operator on board, was asleep in his cabin when the crash occurred. Thrown out of his bunk by the shock, he recovered sufficiently to get into his clothes and hurry to the *Republic's* wireless cabin. Although its outer wall had been shattered,

the instruments fortunately were safe. But the light overhead flickered as he arrived, flickered again—and went out. The dynamos had failed. There was water in the engine room. Quickly he switched the spark transmitter to the auxiliary battery supply, assured himself that there was current there, and went to confer with the captain.

A few minutes later he was back at his key again, and sending out the frantic letters CDQ—the signal then in use and internationally understood to mean "All stations: distress!"

CDQ—CDQ. The operator on Nantucket Island heard it, and the desperate message that followed: "We are shipwrecked. Stand by for Captain's message."

Five minutes after those first blue sparks had leaped, the Nantucket station signaled that the U. S. revenue cutter *Acushnet* had been notified and was making for the *Republic* at full speed. And soon word came that five other ships had heard the call and were responding.

The colliding ship, the *Florida*, had not been so badly injured and she was standing by. When it became apparent that the *Republic* was sinking her passengers were transferred to the other boat. And, later in the night, when the *Florida* too showed signs of being unable to stand up under her injuries and her heavy load, the *Baltic* was already on hand to receive the exhausted frightened people from both ships.

Wireless had not been able to dissipate the fog; it had not been able to prevent the collision. But it was responsible for the saving of 1,650 lives. For the *Republic* went down in spite of the tow lines that were thrown to her, and the battered *Florida*, which finally reached port so steeply tilted that she seemed about to dive into the sea, and flying the grim black signals that meant "Not under control," could

hardly have borne them all to safety. Binns was feted and praised for his courage in sticking to his dangerous post until the *Baltic* appeared, and H. G. Tattersall, the Marconi man aboard the rescue ship, came in for his share of glory. Indicative of the strain under which both men had worked was the last message Tattersall sent as the *Baltic* headed for New York with her precious human cargo: "I can send no more. I have been constantly at the key without sleep for fifty-two hours."

The *Republic's* story was repeated again and again in the next few years, with numerous variations. In February 1910 the *Alamo* picked up a CDQ from the *Alaska* and managed to save its 46-man crew. In the same month the Pacific liner, *Kentucky*, sank on her maiden voyage—but a wireless message had been sent out in time and all aboard her were saved. In April of that year the North Pacific Company's *Santa Clara* went down, just four miles off the California coast; but wireless had summoned a tug and no lives were lost. Within a few weeks' time the *Minnehaha* went ashore on Scilly Rock, and once more all aboard were saved by a quick response to her message of distress.

In December the *Olympia* of the Alaska Steam Ship Company struggled desperately through a storm that lasted several days and finally drove her on the rocks of Sea Island in Prince William Sound. Her sturdy bulkheads could no longer protect her and the *Cordova* picked up her signals just in time to save the weary crew from a tragic death.

Wireless was doing its job. The public was becoming more aware of its value and of the need for the further improvements Marconi was working toward in his laboratory, and hoping for through legislation. And then the story of the *Republic* and the *Alaska* and the *Kentucky* and the rest

was repeated once more—and this time on such a tremendous scale that the world rose as one man to praise Marconi and to second his demands for better safety regulations at sea.

On April 10th, 1912, the *Titanic* set sail from Southampton on its maiden voyage. Months of labor and $7,500,000 had gone into her great steel hull. She was the biggest ship afloat and the most beautiful. Every known device for the comfort and convenience of her passengers had been installed. She was to be the fastest ship on the seas, and the safest—an irrefutable argument to the hazards of the deep.

The New York press, looking forward as eagerly to her arrival as England had planned for her ceremonious departure, announced:

> When the *Titanic*, which for at least a year will be the largest vessel in the world, steams into the Hudson this week New Yorkers will see a ship that is more than four city blocks long, and which if stood on end would be 181.7 feet higher than the Metropolitan Tower; 270 feet higher than the Singer Building. The 46,328-ton ship is 882 feet in length.

By Sunday, April 14th, the great floating hotel was only two days out of New York. Her passengers—including some of the wealthiest and best-known men and women of two continents—mused complacently on the difficulties of transatlantic crossings in the past, and congratulated themselves on having been born to see a day when sea voyages were as pleasant as a vacation in a well-appointed palace, and so brief that the most harassed businessman could wedge a trip to London between semi-monthly directors' meetings.

At noon the wireless room, which had been busy all morning receiving news bulletins, stock market reports and personal messages for the passengers, picked up a message from the *Baltic*, steaming near by. The *Baltic* was warning her

handsome sister that ice lay only five miles from the *Titanic's* lane. At five o'clock the warning was repeated. The *Coronian*, the *Parisian* and the *New Amsterdam* reported ice fields too. But the *Titanic's* Captain Edward Smith was not alarmed. Ice was not uncommon in the North Atlantic at that season, and surely it was nothing to concern the huge *Titanic*. Proudly she moved on at high speed.

As dusk fell the air grew colder. Passengers put on warm coats and took a brisk turn around the decks before dinner, remarking that the new chill in the air would give them a better appetite for dinner. And then they went inside to enjoy the elaborate fare prepared for them by one of the world's famous chefs.

At 7:15 the *California*, not far from the *Titanic*, wirelessed "Passed one large iceberg, two more in sight to the southward," and at 10:20 added "Stopped and surrounded by ice." But Captain Smith did not change his orders, and the *Titanic's* operator, busy getting news reports from Cape Race, signaled the *California* not to interrupt him further with messages.

At 11:30 the *Titanic's* lookout signaled that large icebergs loomed directly ahead.

First Officer W. M. Murdock, on the bridge, was suddenly shocked into action. "Hard astarboard, full speed astern," he shouted.

The great engines churned with the effort to reverse the enormous ship and swerve its course. But the order had come too late, and the *Titanic* was moving too fast. Her bow swung, but not far enough.

She struck.

Strangely enough, the passengers in the luxurious salons and cabins noticed only the faintest jolt. Some of them were

not aware of it at all. But even as the most observant put the recollection of that tiny jar out of their minds, water was pouring into the forward compartments of the hull and the boiler room, through a 300-foot slash beneath the waterline. The *Titanic's* steel side had been cut for almost half her length, as if by an enormous knife.

The great engines stopped. Captain Smith rushed from his cabin to join Murdock, and was informed that the emergency doors dividing the ship into watertight compartments had already been closed. Neither of them knew yet that the collision had jammed the doors beyond repair. Like their passengers, they were convinced that the *Titanic* would not really be seriously harmed by anything—nothing was big enough to hurt her, nothing was strong enough to destroy this man-made leviathan. Captain Smith sent officers below decks to report on the damage, and then went calmly himself to the wireless cabin.

"We've struck an iceberg. I'll know shortly what the damage is. Don't send anything until I tell you, but stand ready."

John Phillips, the senior operator, stood amazed, staring after the captain's broad retreating back.

The *Titanic* in trouble? But, no—that was absurd, of course. He looked at his transmitter, which had been such a convenience to the wealthy men and women aboard. Was it possible that he might soon be sending out over it a call for—? Nonsense. He smiled, but he did wake up young Harold Bride, the 22-year-old junior operator.

"We've struck a berg. The captain wants us to stand by."

Bride's sleepy eyes opened wide and he jumped up. "No! But it isn't serious, is it? I mean—"

"It couldn't be."

Ten minutes later Captain Smith returned. "Send the call for assistance—the regulation international call. I'll send our position down to you right away." And he was gone again. The reports his officers had brought him were not encouraging.

"CDQ—CDQ. Come at once, we've struck a berg. It's a CDQ, Old Man." Phillips' hand was steady.

"Send the new signal—the SOS," Bride suggested. "It may be your last chance to use it." And they grinned at each other over what still could not seem otherwise than a joke.

The *Frankfurt* was the first to answer. "All right," she signaled, "stand by." But she was 140 miles away.

And then the *Titanic's* captain visited the wireless room again. This time he was tight-lipped. He gave Phillips his position and he added, "Keep sending."

And this time Phillips and Bride realized the truth of the situation.

"CDQ—SOS—CDQ—SOS." Out flashed the little signals, tossed into space from the ship that could not ever be—the world had been sure—affected by the ordinary dangers of the sea.

Harold Cottam, the *Carpathia's* lone operator, had been turning away from his instruments to go to bed when a sudden whim caused him to flick open his key once more to pick up a few late news bulletins. He conversed with a shore operator for a while, and then tuned to the *Titanic* to ask her if she knew that Cape Race had messages on file for her. When he shifted his key to pick up the reply he was electrified by what he heard.

A CDQ—from the *Titanic?*

It was 12:20. "Shall I go to the captain and tell him to turn back at once?" he asked.

"Yes. Yes."

And a few minutes later Cottam was able to report "Coming hard." The *Carpathia* was 58 miles away.

The *Olympic*, the *Mount Temple*, the *Birma*, the *Parisian*, the *Virginian* and the *Baltic*—all of them heard and all of them responded with word that they were turning immediately in the *Titanic's* direction. But some of them were hundreds of miles distant. And the *California*, which could not have been more than 20 miles from the *Titanic*—she had been talking to her that evening—did not respond at all. Her single wireless operator had gone off duty for the night.

Captain Smith had ordered the passengers on deck, equipped with their lifebelts. And they had come. But their faith in the *Titanic*, and the extraordinary quiet beauty of the night, kept them calm and unfrightened. Even when they were ordered into the lifeboats they were interested rather than terrified. It was, they seemed to feel, a fascinating experience, to witness the *Titanic* competently facing a situation that might actually have been dangerous for a smaller ship. How fortunate they were to be in such good hands. Slowly the boats were filled—with women and children, largely—and lowered into the mirror-still water. Husbands kissed their wives, assured them that of course nothing could happen to the *Titanic*, and promised them that everyone would be on board again in the morning, when daylight proved that the big ship was unharmed.

But the captain and his mate, at least, knew that their ship was filling fast. She could last only a little while longer. And they knew too that there were only enough lifeboats to carry one-third of the more than 2,000 persons aboard. Their only hope was a rescue ship—a rescue ship that might arrive soon enough. In the meantime they were faced with the

alternatives of telling their passengers the truth—and perhaps causing a panic that would cost unnecessary lives; or keeping the truth from them, letting those in the little boats get safely away, and trusting that the hundreds remaining might be saved by a miracle. Captain Smith and First Mate Murdock kept the truth to themselves and waited.

And near by the *California* lay, unaware of the tragedy. The distress signal had gone out, but she had not heard it.

At 12:27 the *Titanic's* wireless became useless. Operators on the ships steaming toward her could no longer hear even the faint click of the emergency apparatus. "Come quick. Our engine room is flooded to the boilers." That was the last message the *Carpathia* heard. And she was still many miles away.

"You have done your duty," Captain Smith told Phillips and Bride. "I release you. Look after yourselves now."

Bride had already fastened a lifebelt to Phillips, while the latter sat hunched over his key. Now, after one last frantic effort, they both left the little room. Bride never again saw Phillips alive.

Suddenly the tilt of the great decks became perceptibly sharper. And then, so smoothly that the ship might have been a toy in the hand of a child, she tilted forward, her prow slipping under the water until she stood almost upright.

The men and women in the little boats sat stunned. The *Titanic* was going. She was not unsinkable. She was mortal, like the smallest sailing craft.

But the incredulous horror that filled their minds was sharpened into unbearable agony when they heard the screams of the hundreds who were going to their death with her. In the darkness of the night, and the enormity of the scene, few of the rescued had realized that there were still

people aboard. They knew the ship had still been crowded when they left, but they had assumed that at the first sign of the tilt the rest of the passengers had also been lowered to safety. Now they heard cries of agony mingling with the great death roar from the ship herself, and they sat transfixed with terror.

Even as they watched, unable yet to comprehend the truth, the *Titanic's* stern settled slightly so that she was no longer upended, and then slowly she slipped deeper and deeper into the water until no sign of her was left.

It was 2:20—less than three hours after that first faint jar which had alarmed no one. And the *Titanic* was gone. With her had gone 1,517 persons—crew members who had stuck to their posts until death snatched them away, steerage passengers hopefully setting out from their homes in the Old World to find a new and more prosperous life in the New, prominent men and women in the world of business and the arts—all of them cut off in the midst of their proudest journey, as if fate had decided to play a gigantic trick and had chosen the most unsuspecting subjects in the world to play it on.

At a few minutes after four that morning the *Carpathia* arrived on the scene, and the chilled, silent people in the little boats were taken on board. Sadly, as the dawn broke, they and their rescuers looked out over the icy waters searching for some sign of the ship built to challenge the sternest storms of the sea. But there was not even a floating spar to show where she had gone down. The *Carpathia* turned back to New York with her sorrowing burden.

Wireless had saved 706 lives. But more than twice that number had been lost—and they too might have been saved if ship owners had been forced to accept Marconi's advice.

The story of the *Titanic* was written deeply in the annals of the sea. The world praised Marconi, and the brave men who had used his invention so well; and insisted that never again should lack of operators cause another tragedy as unnecessary as this had been. And they further supported agitation for a better control of wireless; for the *Carpathia's* reports had been so garbled by the hundreds of messages hurled into the air when the first word of the *Titanic's* disaster had been received, that not until she actually docked was the true story known. Relatives of *Titanic* passengers had been unable to discover whether the members of their families were lost or saved, and their suffering had been almost as great as that of the men and women who huddled in the little boats and wondered if they would ever be found in the vastness of the Atlantic.

Other lessons too were learned. Ships were never again allowed to put to sea so inadequately equipped with life boats. The construction of ship bulkheads was studied and revised. And public feeling was aroused to a fervor that eventually resulted in an ice patrol of northern waters.

But it was generally conceded that wireless was the hero of the occasion. Without it the loss of the *Titanic* might have remained forever a mystery. One of the survivors echoed the sentiments of many when he said, "In the midst of our thankfulness for deliverance, one name was mentioned with the deepest feeling of gratitude: that of Marconi."

CHAPTER SEVENTEEN

WIRELESS BEGINS TO TALK

THE SECOND decade of the twentieth century will probably always be best remembered for the war which shook the world into chaos, disrupting ordinary progress in most fields. But in the realm of wireless telegraphy and telephony events took place during that period which, although they seemed relatively unimportant at the time, were to play a great part in the slow march of social change.

The first weak mutterings of Fessenden's and de Forest's voice transmission were growing in volume and sureness, until the ears of electrical engineers all over the world bent to listen. The spark was being abandoned as a generator of Hertzian waves; those it produced were erratic and broken, they could not be held to a set frequency, and the spark itself

made so much noise that no voice could be heard above its roar. Fessenden had pointed the way to a more satisfactory generator; his idea for a high-frequency alternator had been worked out for him by Steinmetz, who built one with a 10,000-cycle frequency. Then another American, Ernst F. W. Alexanderson, constructed first a 50,000-cycle machine and later one of 100,000 cycles. Rudolph Goldschmidt in Germany and Marius Latour in France also produced giant generators. Soon these high-speed monsters began to replace the arc transmitter, which had itself replaced the spark. Experimenters who had been calling for continuous waves were finding their answer.

And now those experimenters set out to harness their new wave—to make it carry on its back a wave caused by a man talking, an orchestra playing, or any other sound audible to the human ear. This harnessing process came to be called *modulating*, and the original wireless wave began to be referred to as the *carrier wave*, because of the new function it was being taught to perform.

With this development the Fleming valve, or tube, as improved by de Forest, came into its own. It had been used as an amplifier, to strengthen the feeble signals that reached an aerial; but in 1913 it was first tentatively put to a new use—one that was eventually to mean the end of even high-frequency alternators as generators of wireless waves.

In three different countries patents were filed almost simultaneously by three different experimenters, for a method whereby the three-element valve (the vacuum tube with the filament, plate and grid) might serve as a generator of electric waves. Dr. Alexander Meissner in Germany, C. S. Franklin in England and Major Edwin H. Armstrong in America—all of them suddenly saw the silent, softly glowing tube as

a source of power that might some day send clear voices and faithfully reproduced music all over the earth. It is true that for some years after 1913 bigger and more powerful alternators were designed and installed, but from that date on the mechanical production of electric waves fought a losing battle against the miraculous tube with its swiftly leaping electrons.

And what was Marconi doing while these advances were being made? He was, of course, in close and constant touch with all of them, but in his own laboratory he was chiefly concerned with the improvement of the Bellini-Tossi direction finder. However, there were outside influences which prevented him from spending every one of his waking hours at a work bench. For one thing, he was now a family man—the father of two children. Degna had been born in 1908 and Giulio in 1910; Gioia was to be born in 1916. Marconi was known to be fond of children, but little is known of his relations with these three. Giulio must have followed his father's experiments with interest when he became old enough to understand them, for when he was a young man he came to the United States to work for a time in the field of radio.

A severe accident in 1912 robbed Marconi of many valuable hours of research—and nearly robbed him of his eyesight. For days his family, his friends and the world of science anxiously awaited word as to whether Marconi would ever be able to work again.

Marconi had been a guest at the Royal Hunting Lodge at San Rossore, and it was on September 25th that he set out on a motor trip from Spezia to Genoa. He was driving his own car—automobiles, like all new inventions, fascinated him—and driving it at top speed in order to mount the hill

up which the curving road ran. Another car, descending the hill, encountered his at a sharp turn—and the two crashed. Marconi was found stunned, clutching the wheel, his face streaked with the blood pouring from a gash in his forehead.

That evening news went out over Italy that Marconi was at the Naval Hospital in Spezia. King Victor Emmanuel immediately ordered that all possible care be taken of him, and specialists were called in to confer on the injury done to his right eyeball when it had been pierced by a splinter of glass. Examination proved that the optic nerve had been affected. The eye grew rapidly worse, in spite of all that could be done, and the sight of both eyes began to decrease rapidly. The well-known Italian doctor in charge of the case summoned a world-famous specialist from Vienna. They agreed in consultation that the injured eye would have to be removed if Marconi's sight was not to be completely lost.

Marconi accepted the decision calmly and insisted upon walking unaided to the operating room. The operation was a success, soon he could be seen out driving once more, his head swathed in bandages, and by November 1st he had been fitted with an artificial eye so skillfully made that many persons meeting him face to face in later years were unable to distinguish it from the real one.

He had suffered severely, he had lost important time, and the use of one eye. But all these things were unimportant as compared to the results of another "accident" which befell him at about the same time. This one became known the world over as the "Marconi scandals," and might well have meant complete ruin for the inventor. The story of the "scandals" is a complicated one, but its essence was this: when it became known that Britain contemplated an enormous network of wireless stations linking together the

farthest outposts of the Empire, stocks of the Marconi company soared dramatically. It was believed by many that unscrupulous persons had taken advantage of their own inside knowledge that such a scheme was being contemplated, had manipulated the stocks accordingly, and stood to make a great deal of money at the expense of the British government. Several British cabinet members were among the accused, and the case rapidly became one of the foremost political issues of the day. Parliament appointed a special committee to investigate the affair, and Marconi and many members of his company were called to testify. The newspapers of the day printed dramatic headlines to the delight of the public.

Excitement raged for months before it finally died down with the publication of the special committee's report stating that ". . . no minister, official or member of Parliament . . . has utilized information coming to him from official sources for the purpose of investment or speculation in any such undertakings." No actual blame had ever attached itself to Marconi, but his name had appeared so frequently in connection with the stories, and the term "Marconi scandals" had been so widely used, that his indignation was considerable.

"You see placards, 'Marconi Scandals,' 'Marconi Scenes,' " he declared once to the critics, "and I strongly object to my name being a byword in politics and a peg on which to hang all sorts of scandalous accusations in which it is not suggested by anyone that I am in any way concerned."

The newspapers did their best to formulate a nation's apologies. The London *Chronicle* declared:

> It is time that this country wiped away the stain that has been put upon him and gave to the discoverer of an invention

> that has not only revolutionized the fabric of society, established a new and cheaper means of communication, saved much valuable property and hundreds of lives, the honor that is due him. It would be only just that the nation should do so, even if his inventions were superseded tomorrow.
>
> Marconi is a benefactor of humanity . . . Marconigrams have been of incalculable value to civilization.

But the Empire network had been delayed. When all was quiet once more the plan was reconsidered, but this time it was the advent of the war that postponed once more its realization.

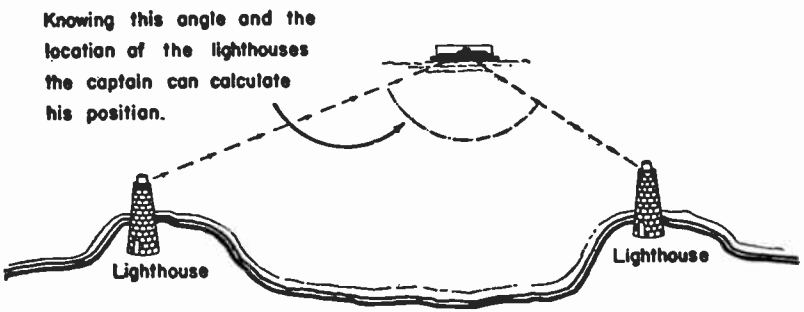
And in the meantime, while the waters of scandal were being churned up and finally allowed to settle again, Marconi—together with Captain Round—was struggling with the direction finder. The Bellini-Tossi contrivance, based roughly on Marconi's directional aerial, consisted of a loop of wire connected to a receiving apparatus in place of the usual aerial, and in such a way that it could be swung around like a revolving searchlight. If a ship operator picked up an SOS, for example, he could swing his loop about until the signals were coming in at their maximum strength; the loop was then pointing out the direction from which the signals were coming, and the captain could let his own ship follow them right to their source.

When Marconi had achieved a fairly dependable instrument he was ready with another suggestion for its use that would be quite as valuable as the tracking down of a disabled ship. Often he himself, on one or another of his numerous ocean voyages, had waited impatiently in a harbor for a fog to lift so that his ship might make port; lighthouse flashes had been invisible, and even the foghorns had been untrustworthy in a world blanketed in heavy mist.

"So why not," he asked Pound, "set up a chain of wireless beacons? We could use already existing lighthouses. Each one would be assigned a definite signal—three one-second dashes, or one three-second dash—anything at all, so long as each was different from every other. Then ship operators could immediately identify a lighthouse by the signal it was sending out."

"But what good would that do? Ships can hear foghorns now, but they don't dare to trust their navigation to them in really thick weather."

"Well, for one thing, you can hear a wireless signal a good deal farther than you can a foghorn. But hearing isn't enough —and this plan will do more than that. Now look: a wireless operator could train his direction finder on a particular lighthouse signal until he finds out exactly where it is in relation to his ship—just as ships pick up each other today. Then he could locate another beacon farther down the coast in the same way. And then," Marconi paused and smiled triumphantly, "then he can tell the skipper exactly where their ship is. It's a simple problem in trigonometry—triangulation."



A. USE OF THE DIRECTION FINDER

Marconi's scheme worked, as he had known it would. And it was soon found that a reversal of this process could be

used to give lost ships their bearings even if they were not equipped with the new directional finders. The lost ship could signal two or more shore stations, asking for her position; the shore stations, training their own finders on her, could each wireless the ship the direction at which their loops were then pointing—and the ship's captain, by drawing lines on his chart, could locate the exact spot at which he stood. Or two ships in the neighborhood of a lost ship could serve a worried captain's purpose just as well. Vyvyan tells an exciting story of such an occasion in his *Wireless Over Thirty Years:*

> For several days in the Shetlands area a succession of hurricanes had been experienced, ranging from 60 to 90 miles an hour, and in the midst of one of these storms a trawler, which had been battling with the seas, received the following message from the Grimbsy trawler *Veresis* which was homeward bound with a crew of 12 from Iceland: *Have been swept clean, losing bridge, both compasses and boats, crew all safe but not sound. Will any ship fitted with direction finding wireless take a bearing on us and come and give us a compass. Have been dodging about in hurricanes for thirty-six hours. Think we're somewhere off the Faroes.* Seven trawlers responded to the call for help and the *Veresis* was able to set a course for Cape Wrath, helped on her way by other ships fitted with direction finders.

And then there is another story. On October 11, 1913, early in the morning, ships' operators in mid-Atlantic picked up the message which they all listen for and which they all dread: SOS SOS. On nine ships of six different nations men bent closer to their instruments, and a moment later they heard the rest of the story: the S.S. *Volturno,* bound to New York from Rotterdam and carrying 600 persons aboard, was afire! Within a few moments the nine captains had the news,

and they all turned their ships toward their stricken sister.

Bucking a fierce Atlantic storm they hastened toward the *Volturno's* announced position at 48.25 N. Latitude, 34.33 W. Longitude. The S.S. *Carmania* arrived first, having used her direction finder to locate the *Volturno*, by this time drifting helplessly twenty miles from the given location. But the *Carmania* could offer no practical aid in the face of the gigantic waves that lifted their roaring heads between the two ships. Shortly after three in the afternoon the *Seydlitz* came up, and on her heels the *Grosser Kurfuerst*. By nightfall all nine of the rescue craft had arrived, and their passengers and crew watched the flaming ship with its frantic passengers, clinging now to the rails in an effort to avoid the licking fire that escaped through every opening in the ship's hull. Some became hysterical and jumped overboard, preferring death by drowning to death by fire.

The *Volturno* launched lifeboats, only to have them smashed against the ship's sides or overturned by the towering waves. At nine o'clock in the evening the *Grosser Kurfuerst* succeeded in getting a single boat safely into the water; searchlights played on it while the sturdy crew battled it toward the *Volturno*. Two hours later it returned with 21 rescued persons. A second boat crew volunteered and by two o'clock in the morning 11 additional survivors were landed on the German liner.

The *Volturno's* skipper, hesitant to add further loss of life to the present toll, wirelessed the ships not to attempt to launch another boat. All through the night the helpless flaming hulk rose and fell in the continuing storm, and all through the night those on board the rescue ships watched with mounting horror.

But wireless was again put to work. The *Carmania* had

established contact with the tanker *Narragansett*, and at five in the morning the low-lying craft arrived—hoses ready to release its cargo of tons of heavy fuel oil. Gradually the oil calmed the tossing waters, and once more the crews prepared to launch their boats. As the sun came up and—miraculously—the wind died with the dawn, the little boats made their way across the oily swells to the fire-gutted *Volturno*. They returned finally to their home ships with nearly 500 passengers and crew—every person still aboard. All on the *Volturno* had been saved, except those who had jumped to their death during the terrifying night.

The lessons taught by the *Titanic* disaster had been well learned. Emergency batteries had kept the *Volturno's* wireless alive for many hours after the engine-driven dynamo had failed; constant manning of the receivers aboard ships had resulted in ten responses to the call for help. And the newest device of wireless, the direction finder, had proved its worth conclusively; without it the rescue ships might never have been able to find the helplessly tossing shell.

And now the ominous rumblings of approaching war were growing louder and louder. Germany, aware that England would sever cable connections if and when a war started, was working feverishly to perfect a communication system that she could rely on. At Nauen, near Berlin, was erected an enormous wireless station that was to be the center of a vast network of such stations; it had a 300,000-watt transmitter and its mammoth aerial was supported on steel masts that rose 750 feet into the air. It could reach other new German stations as far distant as Togoland in Africa and German-owned Pacific islands. In the United States a German super-station with an aerial more than 800 feet high was

constructed at Tuckerton, New Jersey, and another was erected at Sayville on Long Island.

Marconi's own private battles with Germany were not yet settled when June of 1914 finally echoed to the sound of the shot that signaled the beginning of the war. He had just been awarded the decision in a suit against the National Electric Signaling Company of Pittsburgh, at the close of which the presiding justice, Judge Van Vechten Veeder, had stated that Marconi's tuning patent, together with the Marconi-owned Lodge tuning patent, comprised the basis for wireless telegraphy; this suit put the Pittsburgh Company out of business and virtually awarded to Marconi the control of wireless in the United States. In 1915 Judge Veeder was hearing another case in which the 40-year-old inventor was defending his patents. This time the action was against the Atlantic Communication Company, a German-owned firm using *Telefunken* apparatus and established in the United States as part of the German wireless web. But the case was still in progress when Italy joined England and France in the war against Germany, and Marconi asked for an adjournment in order to return home—leaving German interests in control of the American links in their chain; they maintained that control, to their own great satisfaction, until the United States entered the war in 1917.

Marconi would have been a rich prize for the Germans to capture, and unusual precautions were taken to guard him aboard the liner *St. Paul*. According to the New York *Tribune*

> His name was not on either the regular passenger list or the pursers' list. There was a general tacit agreement among passengers that if the *St. Paul* was stopped by a submarine and

Mr. Marconi's person demanded we all would "lie like gentlemen."

Meanwhile Mr. Marconi removed all labels from his luggage . . . and got into clothes suitable for slipping into a hiding place somewhere down in the bowels of the ship next to the keel, where the chief engineer said the captain himself would be unable to find him.

We had a concert that night at which Mr. Marconi was to preside. The programs were inadvertently printed with his name as chairman. The captain ordered all programs destroyed. When the concert began the historian, Mr. Trevelyan, took the chair saying, "We were to have had the pleasure of having Mr. Marconi preside, but unfortunately he is not on board."

The *St. Paul* reached its port safely, although a London dispatch claimed that it had been chased by a German submarine for a long distance.

Italy had recently made Marconi a Senatore—an honor reserved for recognition of remarkable distinction in the fields of art, literature or science—but it was as a working scientist that Marconi thought of himself, and it was in that capacity that he had offered his services to his country.

He undertook some experiments with short waves, thinking their directional characteristics might make them particularly useful for the secret communications demanded by war conditions. And they proved so successful that he sent a message to Franklin in London, suggesting that he work along the same lines.

In the meantime the German stations in the United States were thundering their messages to the Central Powers, and keeping in touch with ships at sea; German submarines communicated with each other by wireless, and merchant ships

conversed with battle cruisers. And, to Germany's surprise, England made no attempt to interfere with the intricately-coded messages; it would have been a simple matter to "jam" them beyond understanding with meaningless dots and dashes.

But England, had Germany known it, much preferred leaving the messages clear and comprehensible—because she was reading them herself with a good deal of profit. A German cruiser, sunk in a naval engagement with the Russians, had been investigated by a diver sent below by the British Navy; the ship's strong box had been cracked open—and there, for England to use, lay a good copy of the German secret codes. Not long afterward a wrecked submarine yielded to the British Intelligence a new and revised copy of the codes, and listening to the German stations became even more advantageous. By the time Britain was faced with a new cipher for which it did not possess the key, her decoders were sufficiently well versed in the German methods to unravel its mysteries in short order.

In America, enjoying an uneasy peace for the first three years of the World War, Alexanderson continued to improve his high-frequency alternator. He finally achieved one so successful that Marconi made a special—and hazardous—trip to this country to see it in 1916. The Allies had needed improved transmission—and they had turned to the United States to get it.

But even though American scientists were striving to improve wartime communications, and making outstanding contributions to that field, there were some of them who could not resist spending some of their spare time on the fascinating new possibility, voice transmission. The American Telephone and Telegraph Company, which had bought

the rights to de Forest's three-element tube, had succeeded in using it to attain a telephone conversation between New York and San Francisco; that had been done by the use of regular telephone wires, but the role in the experiment played by the little glass tube had been so well done that a more ambitious plan was propounded for it.

Scientists already knew that the tube could be used to generate oscillating current, but they knew too that it generated it only in small quantities. If one wanted, for example, to attempt the transmission of voice across the Atlantic, it would be useless. But what about using many tubes at once? That was the scheme they were determined to try. At the Arlington, Virginia, navy station 500 tubes were joined together; they generated a powerful high-frequency current. And, while scoffers still laughed at the idea of so fantastic a thought, a voice was sent against the microphone in the Arlington transmitting room—and picked up in Paris! It seemed incredible to many, but it was unmistakably true. As if all the elements were conspiring to make this success even more spectacular, Honolulu, on the opposite side of the world, reported that it too had heard the transatlantic conversation.

De Forest himself, remembering that he had actually succeeded in broadcasting the singing voice of Enrico Caruso during a memorable experiment in 1910, undertook in 1916 a series of regular broadcasts in the Columbia Phonograph Laboratories in New York City. Later in the year he moved his equipment to the Bronx, and from there he sent out the first news item ever broadcast: the results of the Wilson-Hughes presidential race. Newspapers had carried an announcement of what he was to do in advance, and every amateur for many miles around endeavored to get his set in

good condition for the history-making event. The New York *Times* said the next day

> The Bronx produced an election-night innovation when shortly after dark, last evening, the de Forest radio laboratories in Highbridge began flashing returns by wireless. Amateur operators within a radius of 200 miles had been forewarned of the new information service, and it was estimated that several thousand of them received the news, many of them through using the newly manufactured wireless telephones.

American scientists were building the foundation for what would soon be known as radio.

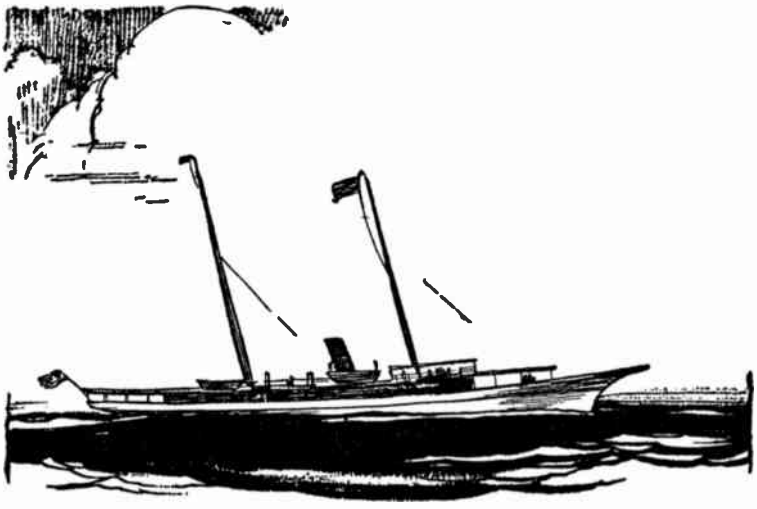
And then came 1917 and the entrance of the United States into the war. Now her scientists were kept busy with the designing and manufacture of weapons of defense and destruction. Now, finally, the German stations on her shores were silenced. The weary months dragged by and finally, in October 1918, occurred an event in which wireless once more played its part in the making of the history of the world.

About noon one day the operators on duty in France and England were startled to hear their instruments click out an incredible message: POZ-POZ-POZ-deNFF. Was this treachery on the part of their ally, the United States, or was it proof of German spy activities in that country? For all operators knew that POZ were the call letters of the German government station at Nauen, and that NFF was the signature of the United States naval station at New Brunswick, New Jersey. The two had not, as a writer put it, "been on speaking terms for a long time." Had Germany heard the message? And what would she reply? They waited

breathlessly, and a few minutes later they heard Nauen respond "Your signals are fine, old man."

When New Brunswick came on again French and English operators breathed a sigh of mingled relief and amazement. The message, transmitted in plain English, was the first of President Woodrow Wilson's statements to the German people, laying down his suggestions for armistice terms. Wilson's famous "Fourteen Points" had already been announced, and several overtures for peace had been made on that basis. The American President was using the world's newest form of communication to enunciate his own plans for the new world that he saw ahead.

Less than a month later, on November 11th, the armistice was signed, and people everywhere could turn their energies to reconstruction and scientific invention aimed at progress rather than at death.



CHAPTER EIGHTEEN

THE WAVES GROW SHORTER

BUT THE end of the war did not mean the end of war work for Marconi. As a representative of his government he had to attend the seemingly endless peace conferences that followed the silencing of the guns and the homeward march of battle-worn soldiers. It was a long job and a wearing one, but a job that he was glad to have a part in.

When he was finally free to tackle his own affairs again, he returned to his laboratory with enthusiasm. During the past years wireless had been overtaking its inventor and in many cases outstripping him. Immense long-wave stations were common in every land. The vacuum tube was being perfected to a higher degree of efficiency and developed to the point where it would soon take over the entire labor of wave generation. In the eyes of the world radio was beginning to replace wireless, particularly in the United States,

where broadcasting pioneers were already undertaking the expansion that would eventually result in hundreds of broadcasting stations all over the country.

But Marconi was not in the van of the broadcast enthusiasts. Forty-four years old now, and in the prime of life, he deliberately turned his back on the field that was engrossing so many of his fellow-scientists, and returned with a boy's eager enthusiasm to his experiments of the 1890's. Bigger and better long-wave transmitters were being built everywhere; but his own limited experiments with short waves during the war had left him curious and unsatisfied; now that he could do as he liked once more, these fragile uncertain oscillations beckoned him with a compelling fascination.

His war experiments stood him in good stead. In 1916, remembering the huge copper bowls he had used so many years before, and how awkward they were to handle because they had to be larger than the wave they were to reflect, he had decided to try to substitute for them a reflector made of wires. Behind a transmitting aerial he had constructed a cage-like affair three and one-half times as large as the wave length he intended to use. Communication up to six miles was the result of his first tests. The signals were clear and understandable and—what was more important—it was apparent that the wireless waves had definitely been directed by the new type of reflector.

Franklin, in England, had read Marconi's report with interest and immediately undertook to follow his chief's instructions. With a spark transmitter, a three-meter wave and a wire reflector, he had achieved, by 1917, a distance of 20 miles. But the use of a spark was irksome to Franklin. He was one of the three men who had worked out methods for using the vacuum tube as a generator of waves, and he at-

tempted now to generate short waves by this method. Unfortunately the tube then in use broke down when he tried to force it to generate millions of waves per second. So Franklin put aside these experiments for a time and concentrated his efforts on the development of a short-wave transmitting tube.

By 1919 he had succeeded. And by that time Marconi was at last free to devote himself to this challenging job. Together the two men settled down to work in earnest.

Marconi sailed for England in the yacht he had just purchased—a trim 730-ton, 220-foot ship which, before the war, had belonged to the Archduke Stefan of Austria. England had commandeered her at the beginning of the conflict and she had served a period of honorable duty, flying the flag of the British Admiral who directed the mine sweepers cruising the North Sea. Now she was to serve as a floating laboratory for important new experiments, and a home-at-sea for a man who was always happier walking a deck than strolling through the finest park in the world. Marconi frequently insisted that he would have made a fine sailor if chance had not cast him as an inventor instead.

The new possession was christened the *Elettra*—which is the Italian word for electricity—and in England she was fitted with the most modern wireless equipment available. Long-wave and short-wave aerials were stretched between the two high masts, and lead wires ran in to the wireless cabin.

"I used to have to pretend that I liked fishing, in order to get off by myself in a boat and think," Marconi grinned. "Now I don't have to pretend any more."

He and Franklin decided to experiment with a 15-meter wave—somewhat longer than the one they had been using. The *Elettra's* equipment and that at a station in Carnarvon,

in Wales, were adjusted to that length, and Marconi put to sea. Microphones replaced the old telegraph keys; the test was to be made with voice transmission.

Marconi sailed up into Kingston Harbor, nearly 80 miles from the Carnarvon transmitter, and they were ready to begin.

"Hello, hello," Franklin said into his microphone. "Calling *Elettra*. Are you getting me?"

"Marconi here," the answer came back. "Signals coming in fine. Voice good and clear."

The middle-aged inventor was as gleeful as a boy. This was fun! These short waves were a new field. There were no rules to go by. He and Franklin would have to feel their way along. It was the sort of job he liked best—the sort of job he felt most at home in.

They decided to experiment over land, in order to discover what effect the earth would have on their small waves. Two stations were set up 100 miles apart and, by using only 700 watts of power, they achieved good speech reception over that distance. Bridging 100 miles with a mere 700 watts seemed a miracle, and left them as puzzled as they were triumphant. What invisible force was helping the waves in their flight? Was it the reflectors that made all the difference? Were they concentrating the power so well that from now on 700 watts would do the work that thousands had previously been needed to perform?

Marconi's reaction to a puzzle was always immediate. "We'll pull down the reflectors," he said decisively. "Then we'll know how much they've been contributing."

Down came the wire cages. And the tubes were turned on again.

"Hello, hello," Marconi called. "Franklin, are you get-

ting me?" He listened intently for an answer, headphones pressed close to his ears.

"Not very well." The response was so faint Marconi could scarcely understand the words. "I guess we need them, all right."

Yes, the reflectors were apparently necessary. Having come to that conclusion they then set to work to determine, by careful measurements, exactly what the reflectors meant in terms of increased efficiency. Days of testing resulted in an astounding array of figures: reflectors increased the energy received 200 times!

"No wonder 700 watts did that job," Marconi murmured.

"But that can't account for everything," Franklin said. "We know that short waves go off in straight lines. What brings them down to our receiver 100 miles away? Surely the reflectors aren't responsible for making the short waves follow the earth's curvature—and that's what they seem to have been doing."

"Must be our old friend, the ionized layer," Marconi said. And he added, smiling, "It's about time it did something *for* us, for a change. It forced us to make our waves longer and longer and more and more powerful, when we were trying for transatlantic communication with long waves. Perhaps now we've found a wave that the ionized strata helps instead of hinders."

"Perhaps," Franklin answered dubiously. "I think I'll—" and with a preoccupied air he hurried off.

A short time later he returned. "I've been going through a whole batch of old wireless and engineering journals," he said, "and I think you're right about the ionized layer. Look at these amateur records. They date back to 1904. I think you'll be surprised."

Marconi bent over the sheaf of papers and then suddenly lifted his head again. "Nineteen four? Wasn't that the year the government limited all amateurs to wave lengths below 200 meters?"

Franklin nodded. "And if the government thought it was going to discourage them—well, just look at that stuff."

He watched with satisfaction the growing look of incredulity and amazement that spread over Marconi's face as he read. Finally the chief leaned back in his chair.

"Some of these amateur signals were picked up at 2,000 miles!" he said slowly. "And many of them used only five or ten watts of power! I can hardly believe it."

"Thought you'd be surprised," Franklin grinned. "I feel like kicking myself for not having looked over this stuff before. But as to what it means—"

The gleam in Marconi's eye had already changed from one of shocked surprise to one of excited speculation. "If even those weak signals got carried such a distance, it means —it *must* mean—that they weren't absorbed at all by the Heaviside-Kennelly layer. They were reflected instead."

"I think so too. They were bounced right back to earth. And now all we have to work out is which wave length is best."

"*And* we have to figure out the angle of reflection," Marconi added. "We'll have to find out at what angle to shoot our waves into the air to have them strike the layer and come back to earth at—Australia, for example."

"We'd better have a bigger station."

"I think so too. Now suppose we . . ." And they were, a moment later, completely engrossed in this new and exciting world.

A 12,000-watt station was erected at Poldhu, with an

aerial that could be adjusted to various wave lengths from 97 meters down. A new receiver was installed on the *Elettra*, but without reflectors because efficient reflectors could not be built in the limited space available. That would not prove a drawback, however, because their calculations proved that whatever results were attained could, if desired, be increased a hundredfold by the use of a directed receiving aerial.

Out to sea sailed the *Elettra* and at Poldhu the short-wave transmitter began to send out its signals. All through the Mediterranean and then down into the South Atlantic the slender white ship moved. During daylight hours Marconi picked up the signals at a distance of 1,250 miles, and at night he received them 2,230 miles from their source. That was gratifying enough, but Marconi had the additional satisfaction of knowing that a receiving reflector would have increased even those distances tremendously.

More tests were made, and still more tests—with reflectors and without—and consistently the short waves proved superior to the long ones. Signals from Poldhu's comparatively small 12,000-watt station were picked up better, many times, than those from the 200,000-watt long-wave stations then in constant service.

And in the United States, all this time, experimenters were working on broadcasting. The homemade crystal set had taken the country by storm. Boys and grown men in crowded cities and on isolated farms hung over their simple little contraptions, headphones clipped to their ears, and listened to the secrets of the ether waves far into the night. Broadcasting companies had been rapidly formed, in most cases by industrial firms with the purpose of advertising their own products. More than 500 sprang into being in the single year of 1922. The air was alive with music and speech. And

when it became apparent that a properly operated station cost tremendous sums of money, Station WEAF solved that problem in a way that was to become widely accepted: it "sold" time on the air to business men who could not afford transmitters of their own. Advertising had taken to the air —and radio had become a thriving and accepted part of American business.

Marconi had kept in constant touch with these rapid developments, and in 1922 his curiosity directed the *Elettra's* course toward the New World and the New World's lusty child, radio. As the ship moved westward across the Atlantic her receivers picked up the babel of sound flying out to meet them—and babel it was, for there was little regulation in those early days and stations interfered with each other with little regard for a listener's ears.

Reporters clambered into boats, and swarmed out to meet the *Elettra* when she moved into the Hudson. As usual their questions—many foolish, some sensible—came thick and fast.

"Is it true that you have communicated with Mars?"

"I'm not trying to communicate with Mars or any other such distant point in the universe. Moreover, I have no plans to do so," Marconi answered patiently.

"Sir Arthur Conan Doyle says that radio might be used to communicate with the spirit world. Would you care to comment on that possibility?"

It wasn't always easy to take these eager young men seriously, and this time Marconi laughed. "I'm afraid that would take too long a wave length."

"Do you think we shall soon be able to telephone to Europe?"

Marconi sobered instantly. This was a real question. "I think we shall, quite soon—sooner than people think."

He had no fear of being quoted on that, no fear that he had prophesied something which might never come to pass. Already he had, himself, spoken over a distance almost as great as that between England and New York, and at that very moment Franklin was working on a new directional aerial. Even the wire parabolic reflectors had proved too cumbersome, and Franklin was experimenting with his own idea of reflectors that were merely straight lines of wire, to be used behind a straight aerial. If his idea proved workable, transatlantic telephony would be close indeed.

Marconi found much to see and do on that trip. After lecturing before the Institute of Radio Engineers—and fascinating his hearers with a demonstration of a miniature transmitter and receiver set up at opposite ends of the room to demonstrate the sharp directional effect made possible by the use of reflected short waves—he sailed on up the Hudson to Schenectady to visit Steinmetz and the General Electric Laboratories. There he also met Dr. W. D. Coolidge, who was working with cathode ray tubes, and Dr. Irving Langmuir, who was working on the problem of larger transmitting tubes. Already Langmuir had built a 5,000-watt transmission tube. As Marconi watched the meters that indicated the inner workings of the silent, glowing, powerful generator of high-frequency oscillations, he must have envisioned clearly the realization of the long-dreamed-of transoceanic wireless telephone conversations and global communication.

When the *Elettra* was turned homeward again in July Marconi could hardly wait to put his newly-acquired information to work. And, too, he was eager to try once more to convince the English government of the possibility and the value of an Imperial communication system. Three times

he had presented his plan and three times it had failed of acceptance; the first proposal in 1910 had resulted in the "Marconi scandals," the second had been accepted but the war had interfered with its realization, and a third proposal in 1919 had resulted in an attack on the Marconi company on the grounds that it was attempting to establish a monopoly of its field. The English Post Office Department had then begun to build its own super-powered long-wave station, with which it was to communicate with other already existing long-wave stations in the Empire.

But now Marconi and Franklin and a few other wireless engineers were fully convinced that the long-distance communication of the future lay in the short wave. With these rapid oscillations a new efficiency could be attained and 12,000 watts made to do the work that had required 500,000. Persuasion of the British government was not an easy task, as Marconi already well knew; and Marconi was also aware that his own accomplishments in the realm of the short wave were not yet startling or conclusive enough to turn the trick. He and Franklin would have to perform some real miracles before the Post Office would give up its own ideas of what wireless should be—and Marconi was in a hurry to get to work.

As soon as he arrived in England he got his staff together and gave them a full report of radio progress in the United States, and of the advances he had seen which might affect their own work on short-wave transmission. When the table around which they sat was littered with diagrams and sheets of mysterious symbols, Marconi turned to Franklin.

"I've been looking at your new experimental aerials, and it seems to me you're on the right track," he said. "If you succeed in replacing the old wire cages with straight re-

flectors, used with straight aerials, we will have gone a long way. I'm going to assume you will succeed."

A brief smile broke through the intense look on his face and then he sobered again. He looked around at the men seated at the cluttered table. Vyvyan was there, Franklin and his assistants, and G. A. Mathieu, who was soon to design the new high-efficiency short-wave receiver.

"But," Marconi said slowly, "even with an efficient aerial system for both transmission and reception, and even with new tube transmitters and receivers, our task will be just begun. It's true that when Columbus set sail he was charting an unknown sea—but at least it was a sea he could touch and see and smell. When we begin to chart the sky we will be dealing with an invisible, untouchable mass of ionized gas. We'll have no compass to steer by. And there are no maps." Once more the smile flashed. "But we'll do it," he said.

"I don't quite follow you, sir," a young engineer spoke up in the quiet that followed Marconi's challenge to himself and to them. "You didn't chart the ionized layer when you perfected your long-wave system. And—well, you got along all right."

"Yes." Marconi relaxed as the older men grinned at the youngster's naïve compliment. "I did get along all right. But this is different. In that case we were sending waves out lavishly—just throwing them out, and in all directions. Even with the first directional aerials we were increasing our efficiency only slightly. That's why we had to pour hundreds of thousands of watts of power into the air. Now we know that, with relatively little power, we can direct short waves up against the ionized layer and they'll be reflected down again. If the ionized layer were a flat belt, equi-distant from the earth at all points, our task now would be easy. We

would simply figure out mathematically the angle at which a beam of waves would have to be projected into the air in London to have them bounce down again into New York.

"But the layer isn't that obliging," he went on. "We do know this much: its height from the earth varies with the amount of sunlight. If we wanted to send a beam of waves from England to the United States at noon, say, we would encounter a low layer of ionized gas over the Atlantic all the way, because the sun would then be shining over that whole area. But if we wanted the waves to go on around the world to Australia, we couldn't be so sure of ourselves; as they moved on westward they would pass through a portion of country where it was early morning and then they would cross the Pacific, where it would still be dark. So the height of the layer would vary constantly, you see, and our poor waves would be reflected time and time again—bounced from the layer down to earth, and up to the layer and down again—and always at a different angle."

The young engineer looked stunned. "But—but, what *are* you going to do? A man could never figure out all those angles and—"

Marconi enjoyed being told he couldn't do something; it gave him an opportunity to prove he could. Now he smiled cheerfully at the young man.

"I think maybe 'never' is an exaggeration. Suppose we set up a transmitter and aim it at New York, as a beginning. Then the *Elettra* could set out for the same goal, and we could chart the signals as we crossed. We'd be able to find out how widely the beam spreads, and where its signals are strongest. We'd learn what wave lengths to use at night and in the daytime. Then, if we had made arrangements with

shipping companies allowing engineers to install our equipment on a number of other boats as well, so that similar tests could be going on simultaneously all over the world—well, it shouldn't take so long. Not if we get started immediately." And Marconi got to his feet with an air of decision, as if he expected to board the *Elettra* within five minutes and start out on his voyage of discovery.

As a matter of fact, immediately always meant just that to Marconi; it didn't mean next year, or some vague unannounced date depending upon a score of conditions.

For two years after that conference the research staff worked on the new short waves. During that time the *Elettra* sailed thousands of miles through the waters of the North Atlantic, the South Atlantic and the Mediterranean. Marconi discovered that a shorter wave length gave much better reception during the daylight hours, and they cut their length to 92 meters. He also discovered that static, which so often ruined long-wave reception, interrupted the short waves less; it was often possible to carry on satisfactory communication with Poldhu by his short-wave outfit when the long-wave apparatus was useless.

In 1924—by which date Franklin had also made great progress with beam aerials—Marconi installed a receiving set on the S.S. *Cedric*, on which Mathieu set out for New York. Poldhu was tuned to the 92-meter wave at that time, and was using 20,000 watts of power. When Marconi had made that same trip in 1904 Poldhu had been using 150,000 watts, and had succeeded in transmitting only 1,200 miles in daylight. What would the short waves accomplish with only 20,000 watts?

It didn't take long to find out. Mathieu reported that he

had received Poldhu's signals perfectly at a distance of 1,400 miles in broad daylight. This was progress! But immediately after this news was received, word came from Australia that the signals had been picked up down there, when they had been sent out at night. Twelve thousand miles—and from a small transmitter—was a feat to be proud of.

Marconi determined to try a telephony test to Australia, and on May 30th, 1924, without a reflector, a 92-meter wave was sent flying in that direction—and was received. Voice had leaped nearly halfway around the earth! In June of the same year he flashed a message to Argentina. And during the next month the Marconi company signed the Beam Agreement with the British Post Office—and Marconi was close to another of his goals.

Many wireless engineers, however, laughed when they heard the terms of the agreement. They were certain Marconi could never fulfill the performance demanded: an aerial system that would guarantee concentration of the beam within a 30-degree angle; a sending speed that would guarantee the accurate reception of 100 words a minute; and a schedule that would guarantee reception and transmission 18 hours a day for Canada, 12 hours for India, 11 hours for South Africa, and 7 hours for Australia.

But Marconi ignored their laughter. He had a pretty good idea of what he was going to do. He set out on the *Elettra* to make new experiments with shorter waves than they had ever used before; and came back to report that daylight reception had been further improved. Franklin agreed enthusiastically about the new wave; he had found it much easier to concentrate in a narrow beam. So Marconi followed the road this information opened up: he tried a 60-meter wave, a 47-meter wave and, finally, a 32-meter wave. With

the last he achieved communication with Poldhu during daylight hours even when the *Elettra* was 2,100 miles away.

By October—still in 1924—Poldhu, using less than 12,000 watts and the 32-meter wave, communicated with Buenos Aires in broad daylight—a distance of some 6,000 miles.

Now the Marconi company was ready to begin establishing short-wave stations for the Post Office Department, with every assurance that they would prove successful. The aerials were designed by Franklin, the receivers by Mathieu, and Vyvyan built the stations.

Milestones in the world of wireless and radio were occurring with increasing rapidity. The dirigible, *Los Angeles*, equipped with wireless, crossed the Atlantic. Cape Town in Africa picked up a radio program from Station KDKA in Pittsburgh loud enough to rebroadcast it. Early in 1925 commercial stations in the United States, which had grown tremendously in numbers and popularity, began to apply for short-wave licenses for transoceanic communication. Later in that year the inauguration of Calvin Coolidge as President of the United States was broadcast by 20 stations in a chain hook-up. In that same year alternating-current electric tubes were introduced and all-electric radio receivers began to appear on the market.

In 1926 Vyvyan saw fulfilled a prophecy Marconi had made when the *Philadelphia* docked in New York in 1902. The inventor had said then that it would eventually be possible to send a message entirely around the globe and receive it again at the point from which it had been transmitted. He had added that it did not seem to him a particularly practical thing to do, and so it wasn't. But it was a thrilling proof of the power of wireless transmission when, at the opening of one of the Marconi beam stations, Vyvyan watched a signal

flash and then saw it recorded three times—1/7th of a second apart—as the impulse circled the world and registered itself each time it passed its point of departure.

On the 30th anniversary of his first patent—on June 13th, 1926—the city of Bologna gave itself to Marconi. Its streets and public buildings were gay with colored bunting and flags. The King wired a message of congratulation and numerous speeches praised the inventor as a scientist and as a man. Marconi himself told of his early trials and of the slow march of progress that was now hastening to a run; and, with his usual generosity, he paid tribute to the contributions to wireless and radio made by the scientists of the United States, England and Germany. The crowd cheered itself hoarse, and the man they honored was deeply moved. Ovations were fairly ordinary events in his life by this time, but Bologna had always had a special place in his heart and her acclaim meant a great deal to him.

And even as Marconi spoke to his old friends and neighbors radio was moving forward. A single day often witnessed as dramatic a display of change as years had shown in the past. On the night of September 23rd, 1926, radio fans all over the world heard a blow-by-blow broadcast of the Dempsey-Tunney heavyweight championship fight. Baseball's World Series was broadcast for the first time in that year too, by the WJZ network. In November the great National Broadcasting Company was formed, with WJZ and WEAF as key stations. And on January 7th, 1927, another Marconi prophecy came true: a transatlantic radiotelephone circuit was established between New York and London.

Marconi's first marriage having been annulled by the Vatican Court he was, on June 12th, 1927, married to the Countess Maria Cristina Bezzi-Scali, beautiful daughter of an

aristocratic old Roman family. Hundreds of friends and associates sent their congratulations, and it was in a new mood of quiet personal happiness that Marconi set sail with his bride in the fall of the year for the United States. Just before the ship docked at the end of what had been his 85th crossing, he amazed members of the crew by sending a wireless message to Rome by short-wave beam at a speed of 200 words per minute. One more of the still-lingering criticisms of wireless—that it wasn't fast enough—had been effectively answered.

On October 17th an enormous crowd braved a heavy rain to hear the inventor of wireless speak again before the Institute of Radio Engineers. Marconi thanked his old friend, Michael Pupin, who had introduced him, and then described his recent short-wave work. He expressed his belief that long-wave stations would eventually be obsolete, and took to himself all the blame for the time that had been "wasted" on them.

"I admit that I am responsible for the adoption of long waves for long-distance communication," he said. "Everyone followed me in building stations hundreds of times more powerful than would have been necessary had short waves been used. Now I have realized my mistake and this new system we have developed, when universally applied, will result in sweeping cuts in rates. The public will benefit."

Speaking of the newer fields of wireless he added, "Short waves cannot but enormously assist in rendering more practical the systems of picture and facsimile transmission, including television. . . . Looking back to our old difficulties of only a few years ago, the ease and perfection recently achieved by radio, especially in regard to broadcasting, appears little short of miraculous. It shows what can be done

by the combination of a great number of workers all intent on securing improved results. And how many, who began as amateurs, have contributed in one way or another to this progress and this success?

"We are yet, however, in my opinion, a very long way from being able to utilize electric waves to anything like their full extent, but we are learning gradually how to use electric waves and how to utilize space. . . ."

The rest of his stay in New York was, this time, a constant round of entertainment by public officials and important private citizens, intent upon honoring the newly-married Marconis. They both enjoyed themselves, but soon they were on the high seas heading eastward toward Italy again. Marconi's imagination had been fired by the thought of an even shorter radio wave—a wave less than 10 meters in length, that would oscillate more than 30,000,000 times a second. Already, before he had had a chance to work with them, his head was full of possible new uses for these ultra-short waves.

At 57, Marconi was as impatient to experiment as he had been as a boy. He had to get back on the *Elettra* and try out his new idea.

CHAPTER NINETEEN

SIGNING OFF

ANY STUDY of Marconi's life and work must result in the realization that "accidental discoveries," which have made so many men famous, played small part in his career. From that day in the Biellese mountains, in 1894, when he read of Hertz's life and death, Marconi knew just what he wanted to accomplish and pretty much how he intended to go about it.

The Hertzian waves, which had been a laboratory plaything to many scientists, immediately were seen as a possible source of wireless communication by the young Italian; and he worked with them until he had achieved his goal. His tuning apparatus and his first directional aerial were both the results of an idea carefully and laboriously translated into actualities. The successful use of 30,000-meter waves for long-distance communication was the end of a long arduous road—but he had known where the road would lead him from the moment he took the first step.

Vyvyan has pointed out—and Marconi himself was aware

of it—that many years would have been saved in the development of transatlantic wireless if Marconi had, by accident, built his early Poldhu and Glace Bay stations to transmit on long wave lengths. But Vyvyan adds that Marconi didn't work that way—that he believed in taking one step at a time and making careful observations as he went along. These observations, once made, were never forgotten. Marconi never had the gratifying experience of realizing that he had, to his own surprise, discovered or invented something; he dreamed of his inventions long before they had taken shape under his fingers and then, wide awake and tireless, he fought his way over every obstacle and every hardship that stood between him and his dream.

It is because Marconi never forgot what experience taught him that his life's work could be pictured—like the radio wave he utilized—as a cycle. In the beginning the waves he employed to click a coherer across the length of his third-floor workroom were tiny waves. He forced them to grow until they were powerful giants leaping across oceans in ethereal seven-league boots. But the tiny waves had stuck in his mind. And, when his own understanding of the invisible force he worked with had been enlarged, he began to realize that the largest waves were not necessarily the best waves. At the end of his life he was pioneering again—and out of his pioneering came the world-embracing short-wave beam system.

Once he had been convinced that a 30-meter wave gave better daylight transmission than a 100-meter wave, he followed his usual procedure and changed his apparatus gradually to test out waves of shorter and still shorter length. He finally discovered that waves less than ten meters long behaved unpredictably, and so he had maintained his beam

system transmission on a band varying between 10 and 100 meters.

But his curiosity about the unpredictable acrobats which came to be known as ultra-short waves—those between one and ten meters in length—continued to plague him. And he even insisted, in the face of many who laughed at him, that the very tiny waves—those less than a meter in length, and called micro waves—might have their important uses.

Mathieu, who had designed the short-wave receiver, set to work at Marconi's request and soon supplied him with the necessary apparatus for transmitting and receiving ultra-short waves—including tiny new tubes capable of creating and detecting millions of oscillations per second. The next step in Marconi's plan was the usual one: the *Elettra* was equipped with the new devices, as was a shore station on Italy's coast, and Marconi set sail to try to chart the course of the waves.

It was a difficult task. They seemed at first to behave much as light waves do—to travel in a straight line and to be stopped by an obstacle as light is stopped by a solid wall. But soon events upset that theory; if they had actually been like light waves, they would have been undetectable at a point beyond which light waves issuing from the same source could have been seen. Yet Marconi picked up 5-meter waves 30 and 40 miles from the shore station—a distance great enough to make the curvature of the earth an obstacle to the transmission of light.

In the meantime other scientists had gone to work on the problem. In the United States, in England and in Germany new devices were being designed to send the ultra-short wave into space and to observe its behavior. New theories were formed and upset by the erratic waves' strange antics. Trans-

mitters were set atop mountains and their signals were picked up in cities 300 miles away; London reported the reception of signals from a 5-watt police car transmitter operating on a 9-meter wave in the United States. No beam of light could have done that—so something must be bending the waves around the curve of the earth, although no worker in the field could explain what that "something" might be.

But, unpredictable as they were, the new little waves seemed to promise several new uses. For one thing, they responded to direction even better than the short waves had done; Marconi found that he could beam them just as he did the searchlight on the *Elettra's* bridge. And they were immune to atmospheric noises; this would mean flawless reception regardless of weather conditions, and television broadcasting without the picture-distortion caused by static. Ultra-short wave stations could cover only a narrow range, but even this could be a benefit as well as a drawback; if a station were heard for only 30 miles, it meant that two stations might be erected within 100 miles of each other using the same frequency, but still not interfering with each other. It was a possible solution to the congestion that hampered the expansion of radio broadcasting.

By the time many of the world's radio scientists were engrossed with the ultra-short waves, Marconi had moved on to his next puzzle—the micro waves. Once more new apparatus had to be designed, for no tube of that day could create what he needed—radio waves oscillating as frequently as 600,000,000 times a second. Again Mathieu went to work, again he was successful, and once more the *Elettra* and a transmitting station were equipped for a new experiment. Mathieu could have used the copper bowls Marconi had once purchased for his Salisbury Plain experiments if they

had been handy, for with these tiny waves a solid reflector was possible. The *Elettra* sailed with one on her stern, and the *Santa Margherita*, near Genoa, began to transmit.

But this time, as the *Elettra* neared the optical limit—that is, as it was passing out of sight of the *Santa Margherita*—the signals began to diminish in strength. It seemed as if the micro waves were really optical in their behavior. Marconi, however, was unconvinced. The transmitter was moved to a high tower about 1,000 feet above sea level; and on the yacht's next trip she picked up signals at a distance of 168 miles from land—although glasses trained on her from the tower had lost her when she was 72 miles away. Still somewhat puzzled, Marconi was at least assured of some successful future for micro-wave transmission. Speaking before the Royal Institution, he said:

> I feel that I may say that some of the practical possibilities of a hitherto unexplored range of electrical waves are being investigated and a new technique, which is bound to extend very considerably the already vast field of the application of the electric waves to radio communication. When this is developed it will mean radio service and entertainment free from atmospheric interference. It will be useful for communication between islands and over short distances. Micro waves are unaffected by fog and offer a high degree of secrecy, the latter principally by their sharp directional qualities.

In 1931 he supervised the construction of a powerful short-wave transmitter in Vatican City. For the first time in history a Pope was able to speak to millions of people at once; faithful Catholics all over the world were grateful for Marconi's short-wave beam system. Then, in 1933, he installed micro-wave equipment for communication between the Vatican and the Papal summer residence some 15 miles

away. Parabolic reflectors beamed the 60-centimeter waves back and forth across the intervening hills and trees with perfect results. It was the first practical installation of microwave apparatus and its success stimulated research in the new field throughout the world—research stirred to even more enthusiastic endeavor when Marconi himself shortly afterward picked up a 60-centimeter wave 94 miles from its transmitter. What had caused the tiny waves to pass through mountains and follow the curvature of the earth Marconi did not know—and, not knowing, he would not hazard a guess. But the world agreed with him that further experimentation in this newest realm would have to be done.

And now Marconi was once more obsessed with one of his very earliest ideas: greater safety at sea. Micro waves traveled in a straight line, and a reflector could channel them into a narrow beam. Why not a direction finder utilizing this data—a direction finder that would be far more effective than anything they had ever designed before?

For days he was seen at work on the *Elettra*, moored outside the harbor of Sestri Levante. Two small parabolic aerials were installed on the roof of the bridge, and new apparatus was placed beside the captain's compass. On the roof of a building in the port Marconi men installed other small parabolic reflectors. When he was ready, the inventor invited a group of British and Italian marine technicians to be his guests at a new test he was eager to show them.

The guests joined him and watched curiously while members of the crew fastened canvas screens over all the windows of the little bridge where they stood.

"Are you sure we're going to *see* this test, Senator?" one of them asked jokingly, staring at the heavy cloths that cut off their sight of the deck outside and the blue water below it.

"Seeing isn't going to be important," Marconi answered with a cheerful air of mystery.

At that moment the ship's captain rang for slow speed ahead and the vibrations beneath their feet told the assembled guests that the ship was moving.

"You know, gentlemen," Marconi began, "that the entrance to Sestri Levante is narrow and twisting."

There were murmurs of assent.

"We're going in," the inventor continued, "blind—just as we are. We're not going to be able to see any buoys or landmarks. And we're not going to look at a chart. We'll use this instead."

He pointed to a strange-looking compass, the face of which was painted half red and half green. Above it was fastened a radio loud speaker.

Even as they looked they heard a series of clicks issue from the speaker, and they could see the pointer of the compass swing over into the green half. Instantly the captain turned his wheel until the needle once more lay along the line dividing the two colored halves.

The clicks sounded again, the needle swung toward the red, and the captain righted it by twisting the wheel of the ship.

Curiosity and nervousness were mingled in the onlookers' faces. This was all very fascinating indeed—but what if the ship were to crash as they stood here nodding politely? What did Marconi think he was up to, anyway?

"You see," Marconi went on calmly, "we're receiving two micro-wave beams from shore. They can be heard through the loud speaker and they also affect the needle of the compass. Now—" he paused as the ship was swung once more in response to the swinging needle, and then went on. Only

a twinkle in his eye indicated that he was aware of the uneasy air of the men cooped up with him in the bridge of a ship that might, for all any of them could see, be heading for trouble in that very instant.

"Now as long as the ship stays on exactly the proper course, the compass needle remains at neutral position—neither on the red section nor on the green. As soon as we leave the course the needle swings to indicate which way we must turn to get back on it again—there, you see? We've shifted again. Gentlemen, we're riding a radio beam right into the harbor."

And then he stood quietly, watching the needle shift, watching the ship's wheel turn, glancing now and then at the faces of the men around him, until suddenly the ship's engines died and the vibration beneath their feet had ceased.

Marconi smiled, stepped to one of the shrouded windows, and lifted the heavy canvas.

"You see?" he said. "We have arrived." The *Elettra* was safely in harbor.

Not long afterward ship captains "rode a beam" as a matter of course when fog lay thick over a harbor like an impenetrable blanket; and airplane pilots landed safely when the ceiling was zero and the field invisible to them a few seconds before their wheels touched solid earth. Marconi had found another job for wireless waves to do, and he had taught them to do it superbly well.

In the last ten years of Marconi's life the whole world had been transformed as a result of his youthful belief that communication without wires was possible. World-wide telephony was an accepted fact. World-wide radio was a part of every man's daily life. Television was still in an experimental stage, but its future was clear enough for everyone to see.

Ships at sea and silver craft in the air, in war and in peace, guided themselves by radio and relied without question on the mysterious waves no man had ever seen. Marconi had prophesied incredible things—and then he had made his prophecies come true.

And so when, in 1931, he foretold a development which his fellow-scientists once more regarded as visionary and improbable, most of them listened to him with respectful interest. Marconi was telling them that power would some day be transmitted through what had once been called the ether, but which was now called simply space.

"A great deal is still to be done before such a thing can become an actual fact," he declared, "but I believe it is coming.

"I can hardly conceive of power being transmitted over a range that would carry it beyond the curvature of the earth from the point of generation," he admitted. "But up to perhaps 25 miles, where economic considerations permit, electric power will, I believe, some day be carried without wires."

"Impossible," some of his hearers muttered. "The losses are too great." But others had learned their lesson.

Once they had believed that it was impossible to send a single signal across the Atlantic; now the air over their heads was alive with messages in every language of the world, with music that was gay and music that was sober, with disembodied pictures that could make themselves visible on a screen in all the color and all the lifelikeness of their originals, speaking and moving in a studio miles away. Once they had believed that short waves were useless; now they were being put to work in new ways every day; doctors were using them to create an artificial fever which fought diseases

they had believed incurable a short while before. Radio waves had even been taught to broil a steak or cook an egg.

And so some of the scientists said "Well, it sounds unlikely, but if Marconi says so . . ." Scientific progress was a road of miracles; they no longer scoffed when a miracle was foretold. They waited and they watched, or they returned to their own laboratories to see if they might not bring the miracle to pass themselves.

Marconi's interest in his experiments never died down. But an affectionate public, which had christened him the "Grand Old Man of Wireless" when he was still scarcely more than a boy and the "Father of Radio" not very many years later, left him less and less time for his laboratory. His wife's efforts to see that he was not disturbed were tireless; she was as faithful to her job as Anna Jameson Marconi had once been, and as comforting a confidante for her husband who had had no such warm sympathy since the death of his mother in 1920. But even the Signora Marconi could do little to stem the tide of important ceremonies which constantly demanded Marconi's presence, the numerous events of great significance to wireless or radio which he must attend.

And many of those events were significant indeed. In 1931 the Marchese Marconi—he had been created a marquis by the King of Italy two years before—sat in comfort aboard the *Elettra* and was interviewed by several men in the National Broadcasting Studio in New York. Among those men was David Sarnoff, president of the Radio Corporation of America, who, as a young immigrant boy, had been hired by the American Marconi Company.

The conversation was broadcast to listeners all over America. "Ladies and gentlemen," the announcer's explanation began, "the National Broadcasting Company at this time will

attempt another experiment in long-distance communication. Senator Guglielmo Marconi will speak to us from his yacht, the *Elettra,* which is somewhere in the Mediterranean Sea. We shall now attempt to establish communication with the *Elettra.* Hello! Is that Mr. Mathieu on the *Elettra?*"

And a moment later the listeners heard a second voice. "Mathieu here. Would you like to speak to Senator Marconi?"

And then came the soft-spoken quiet words: "Hello, National Broadcasting Company. Senator Marconi speaking."

The conversation ranged over many topics and ended with a brief exchange between Marconi and the NBC engineers who had made the technical arrangements for the broadcast. It had been Sarnoff who suggested that those young men might like a word with Marconi—and he was undoubtedly right.

In the same year Marconi was asked to illuminate the great statue of Christ which had just been completed on the Corcovado Mountain near Rio de Janeiro. Marconi felt as honored by the city's choice of him for this ceremonious task as the city was honored by his acceptance. From the Coltano Station near Leghorn—afterward named the Guglielmo Marconi Station—he transmitted a Morse signal on two wave lengths; and thousands of miles away, high above the beautiful harbor of Brazil's capital, the great statue flamed into sudden and dramatic brilliance.

On December 12th of 1931 a truly unusual world-wide broadcast took place, honoring Marconi and his great accomplishments. It was the 30th anniversary of that first faint "S" heard in St. John's. Now the Atlantic was no longer an obstacle. In fact the world itself could be circled in the twinkling of an eye—and so this broadcast proved. Listeners

heard speakers in New York, in Washington, in London, Brussels, Paris, Berlin, and Rome, in Rio, Tokyo, Manila, Caracas, Buenos Aires, Honolulu, Ottawa, Montreal and—finally, a second time—in New York. One by one, as plugs were inserted in a New York control board, the voices of more than a dozen countries were raised in honor of one man. And, in London, that man listened and himself took part in the program.

At the end of a brief address in which he tried to express his gratitude for a gesture so literally world-embracing, he said "Perhaps it will interest you if I now repeat the Morse signal of the letter 'S' as I first heard it across the Atlantic in 1901."

But the audience could not hear it as it had sounded then. The three clicks were sharp and clear. Radio could not return to its first feeble infancy even at its master's command; it had grown too lustily and too long under his watchful eye.

The great Century of Progress Exposition in Chicago in 1931 set aside a Marconi Day, and the inventor enjoyed every minute of it, including the luncheon in his honor and his conversation with President Franklin D. Roosevelt. But when the afternoon was drawing to a close, and the other members of his party were tired, he insisted upon inspecting an amateur radio installation at the Palace of Transportation. The boys there were excited when they recognized the quiet man who was asking them so many questions. Finally he turned toward a partially-completed transmitter in one corner and said "This is certainly a fine piece of work."

The boy who had been building it murmured "I guess it can't be *very* good, Mr. Marconi. I mean—I'm only an amateur."

Marconi grinned at him. "I'm only an amateur myself," he confided.

After their Chicago visit the Marconis continued the round-the-world trip on which they had recently embarked. It was intended as a pleasure jaunt, and a rest for the inventor, but everywhere they went he found so much to see and do that he was as busy as he had ever been at home or in London. He told American reporters that he had undertaken this trip in order to learn, rather than to tell others what he was doing himself.

In China, Japan, India—in all the countries they visited—he inspected huge transmitters and receivers, with an increasing realization of the world scope that wireless had now acquired. And everywhere, of course, he was feted and honored. But perhaps the ovation that pleased him most was a spontaneous one that occurred in the Grand Canyon in Colorado before they left the United States. All the cowboys of the district, when they heard that Marconi was in the neighborhood, gathered to tell him how much his invention had meant to them; now, they said, when they were out on the range they no longer felt lonely; radio had made all the difference to them between complete isolation and the sense that the world's news and music was at their fingertips.

When the Marconis finally returned to their home in Italy —they were living in the Odescalchi Palace, a charming old garden-and-sea surrounded house about an hour's drive from Rome—they were bearing the love and admiration of thousands of people all over the world. And they had also brought home countless gifts for their little daughter, Maria Elettra Elena Anna—gifts that had been sent to her by prominent men and women of a dozen countries.

Marconi was overjoyed to see his little daughter again, and settled down to discover how well she had done with her lessons while he had been away. Elettra, as they always called her, had been born in 1930 and she had her father's childhood trick of concentration; she often amused him by waving him away with an impatient hand, when she was engrossed with a book or a puzzle she had not solved. Marconi always smiled and left her alone. He could understand just how she felt.

They were a happy family. And even though Marconi continued to put in long hours in his laboratory he had learned one lesson since his younger days: now he was punctual for his meals. And if he intended to spend an evening at his workbench he always took time out for dinner first—and without urging.

But despite the Marchesa's care Marconi was seriously ill for several months in the winter of 1934-35. The breakdown came on in England and he was not even able to get home for his traditional Christmas with his daughter. By spring he was better, had gone home, and returned to London again. But that fall his wife informed inquirers that he was "very, very tired." Even several weeks' rest in a nursing home failed to revive him, and his friends and fellow-workers realized with a shock that Marconi was no longer able to do the long day's work he had been accustomed to for so many years. They should not have been surprised. Marconi was over sixty; but he had always been so vigorous, so apparently tireless, that they could scarcely believe that his great source of energy had finally failed him.

Two more years went by, quietly, while Marconi rested a little more each day, although he maintained his old lively curiosity about everything that was going on in his world. On July 19th, 1937, he went to the station in the morning

to see his wife and daughter off on the train for a trip to the seaside. When the train had pulled out and he walked slowly back to his car, his chauffeur noticed with alarm that there were tears in Marconi's eyes. Tears were so foreign to his nature that the man was alarmed, but he knew his employer too well to show his worry.

Marconi, however, must have noticed the look of concern, for he turned away with a half-apologetic, half-impatient air. "How silly we become when we grow old," he murmured. "Just like children."

Later that day he admitted to feeling very ill. Doctors were hastily summoned. An attempt was made to revive him with oxygen. But at three o'clock the next morning he opened his eyes for an instant, whispered "I'm feeling awfully ill," and closed them again. A moment later he had died.

Within a few hours messages from all over the world had flooded the quiet house. The world mourned him sincerely, grieving at his death. But the world's scientists knew that Marconi had not died—that no man who had left so much work behind him could ever be anything but alive. Edouard Branly, the Frenchman to whose coherer Marconi had owed so much, said, "Marconi was a great scientist. He was the only man who could have carried on and developed my own finds for the greater glory of science. He had a big heart and his scientific honesty made him recognize the groundwork done by those before him. His steadfast research work merits the utmost praise."

A great heart . . . scientific honesty . . . steadfast research work—they had made Marconi what he was, as a man and a scientist, and they were the things the world would always remember of him, in addition to the actual legacy he had left in his work. Many of those who had been with Marconi

in the early days had died before him—his brother Alfonso and the faithful Kemp among them. But all who were left added their homage to that of the 93-year-old Branly, and to the words of praise sent from kings and presidents and potentates.

Marconi was gone—but he was still alive. Fame is an uncertain thing. Even today few people think of him as the source of the beam system of short-wave radio, as the inventor of the radio compass. To most he is the Father of Wireless, and perhaps after all that is the title which he would have preferred himself. For without wireless none of the miracles that followed would have been possible, and yet wireless itself was the simple idea of an "amateur" who dreamed a dream and worked until it came true.

But uncertain as fame can be, it is impossible to believe that Marconi will ever be forgotten. And perhaps in years to come a certain London *Time's* editorial will be regarded as prophetic:

> When the early twentieth century comes to be surveyed by historians yet unborn, and its great personalities to be estimated, not according to the figure they cut in our eyes, but by the measure of their influence on the world our posterity have inherited, and the lives they live, it is probable that many names now venerated and resounding will sink into a minor repute; but it is difficult to imagine any diminution of the fame of Guglielmo Marconi. He may even be regarded as the supremely significant character of our epoch, the name by which the age is called.

MARCONI HONORS AND AWARDS

1897 Italian Knighthood
1902 Knight of the Russian Order of St. Anne
1905 Knight of the Civil Order of Savoy
Knight of the Italian Order of Workers
1909 Nobel Prize for Physics
1912 Grand Cross of the Spanish Order of Alfonso XII
Grand Cross of the Order of the Crown of Italy
1914 Medal, British Council of the Royal Society of Arts
Knight Grand Cross of the Royal Victorian Order
Senatore of the Kingdom of Italy
1919 Military Cross for World War Service
1927 Silver Medal, International Mark Twain Society
1929 Spanish Order of "Plus Ultra"
Italian Marquisate
1932 Kelvin Medal, Institution of Civil Engineers, London
John Scott Medal, Philadelphia
1933 Grand Cross of the Japanese Order of the Rising Sun
1935 Grand Cross of the Brazilian Order of the Southern Cross
1936 Grand Cross of the Chinese Order of the Jade
Rear Admiral of the Italian Naval Reserve
Also Knight Grand Cross of the Order of Menelik, Abyssinia; Grand Cross of the Order of Pious, Vatican City State; Grand Cross of the Sovereign Military Order of Malta; Grand Cross of the Italian Order of St. Maurice and St. Lazarus
Also Gold Medals of Institute of Radio Engineers, New York; Franklin Institute, Philadelphia; University of Bologna; Royal Society of Rome; Royal Academy of Science, Turin, Italy; Italian Society of Science; New York Electrical Society; Veteran Wireless Operators Association, New York

Also John Fritz Medal, awarded jointly by the Institutes of Electrical Engineers and Mining Engineers; Goethe Medal presented by President Paul von Hindenburg, Germany; gold tablet, Italian Institute of Electrical Engineers; gold tablet presented by the survivors of the S.S. *Titanic;* "Gustave Trasenter" Medal, Liège, Belgium; "Exner" Medal, Vienna, Austria; "Viani" tablet, Humanitarian Society, Milan, Italy; Diploma of Merit in Science, Pontificia Accademia Tiberina, Rome

Also honorary doctor of engineering degree from University of Bologna, University of Pisa; honorary doctor of science degree from Oxford University, Cambridge University; honorary doctor of law degree from Glasgow University, Aberdeen University, Liverpool University, University of Pennsylvania, Louisiana University, Columbia University, Notre Dame University, Loyola University, Northwestern University; honorary doctor of physics degree from Rio de Janeiro University; and honorary professorship of electro-magnetic waves from Rome University