

It was interesting to note that although Marconi plainly claimed for two coils and circuits in tune with one another, the Radio Company was using the arrangement shown in Fig. 6, in which different parts of one coil were made to act as two coils.

Mr. Justice Parker held that this was immaterial—the essential point being that the two circuits had to be in resonance.

During the trial a very happy phrase was used illustrating the relation of the feeding or condenser circuit and the air wire circuit. Counsel likened them to the miser father and the spendthrift son who was always drawing supplies from the old man and dissipating them.

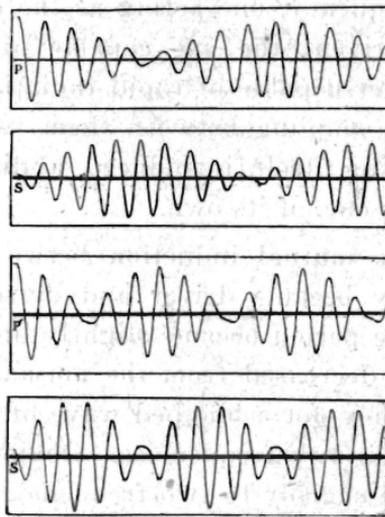
Here then they had got as far as two circuits tuned to the same frequency, one acting as the driver and the other as the driven; the one capable of great energy storage, the other capable of rapid radiation, and with a degree of E.M. coupling between them variable at will. But this coupling itself introduced a difficulty, and a very interesting one, of its own.

Owing to the mutual induction between the circuits they alternately became driver and driven. As driver the natural time period became slightly increased, and as driven slightly decreased from the normal, and the consequence was they got a humped wave of two peaks corresponding to the two frequencies. Obviously it was not possible to tune sharply to two frequencies, and the difficulty was got over by making the coupling very loose, when practically the humps coincide, and otherwise in a most ingenious manner by the Telefunken quenched gap.

The author here showed a model to illustrate the above-described idea. Two small pendulums, and consisting of weights attached to equal lengths of string, were slung, separated by a few inches from a slack string supported at each end by wooden uprights. The two pendulums had

the same period of oscillation, by both being at rest. Then if one be set swinging, representing the oscillation of the driving, or condenser, circuit, the second pendulum (or air wire circuit) would gradually be set swinging and would gradually increase the amplitude of its swing until it had extracted all the energy from No. 1 pendulum, which would then have come to rest, only to start again as the second pendulum returned to it some of the borrowed energy. This interchange of energy between the two pendulums would go on backwards and forwards between the two pendulums until the whole energy of the system was expended (radiated).

Fig. 7 illustrated photographs of the motion of the coupled pendulums, P and S, being the relative movements of the two weights.*



Photographs of motion of the coupled pendulum.

Fig. 7.

If, after No. 2 pendulum had been set swinging, No. 1 pendulum was positively removed from the system, it was clear that No. 2 would go on swinging of its own accord without returning any of its energy to No. 1 pendulum, and this was what happened with the so-called "quenched" gap discharger shown in Figs. 8 and 9.

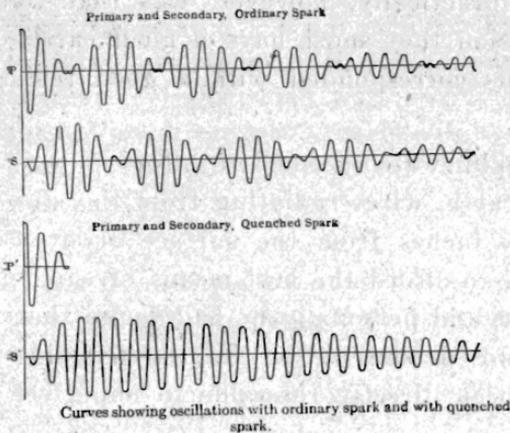


Fig. 8.

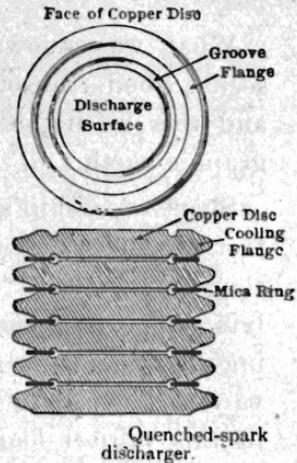


Fig. 9.

The office of this form of gap was to lock off the condenser circuit the instant the first transfer of energy had taken place to the air wire circuit, and thus prevent the second pendulum from returning any of its energy to the first.

Marconi, without using the quenched gap in this form, secured practically the same result by means of his rotary gap which consisted essentially of a studded wheel driven at a high rate, causing the studs to present themselves between fixed electrodes when the condenser discharge took place, to be almost instantly quenched by the removal of the opposing studs. This form of gap had other merits too, but it was impossible within the limits assigned to him to do more than mention the fact.

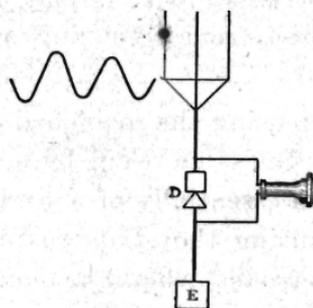
Reviewing the facts that he had so far dealt with, they had seen means adopted to feed a good radiator with persistent oscillations. They had seen the supposed manner in which these oscillations were broken off from the parent aerial and started on their journey.

He said supposed, because he did not think that the method of their breaking off and initial start was known with certainty, nor was the part the earth played much more than supposititious at present.

What was known practically, however, was that to secure good transmission they must have a good earth, and this by no means corresponded with a good telegraphic earth.

Short of a ship's skin, which seemed to afford a perfect high frequency earth, wires radiating from the station and sunk a few inches from the surface or even lying upon it, seemed to afford the best means of earthing a transmitting set, and personally he had found that various troubles he had encountered on the practical side of this subject had been directly referable to imperfect earth.

Let them assume now that their transmitting station being complete, they had launched forth a series of signal waves into space.



Detector in antenna circuit.

Fig. 10.

Travelling outward in all directions from their parent aerial, they might be assumed to strike the distant aerial of their correspondent.

Here they had, instead of the moving armature and stationary field of the familiar dynamo, a moving field of electro-magnetic force, with its electric component disposed as meridians, and its magnetic component disposed as parallels of magnetic energy. Travelling past their stationary air wire (and incidentally he should remark

that the same air wire performed the double office of radiator and receiver) it straightway induced an electric current therein, which was instantly reversed in sign as the hollow of the wave reached it, and which continued to rush up and down the air wire so long as the wave train was passing.

And now again the importance of resonance was felt. If the natural time period of the receiving air wire due to itself and its associated instrument circuits differed widely from the frequency of the reversals or taps administered by the passing wave, even quite delicate detecting instruments would fail to record its passage.

But if it was exactly or nearly in a condition to be thrown into revibration by the passing wave, then the response would be strong, and the receiving instruments would be strongly affected.

In Fig 10 was a receiving circuit in the simplest diagrammatic form. D represented a rectifier of oscillations, and a telephone was bridged round the rectifier or detector.

The signal was heard as a tick for each train of waves passing the aerial, and when the trains or groups succeeded each other with sufficient frequency at the transmitter the sound in the receiver was heard as a pleasant musical note. It must be noted that what was heard was in no sense the frequency of the wave alterations.

It was obvious that these were far above the limits of the human ear; but what was heard was the group or train frequency of the waves—that was, the frequency with which successive groups of waves followed one another from the distant transmitting station.

With the quenched gap of the Telefunken Company this practically coincided with the frequency of the alternator used to feed the transformer, and was about 500 per second, giving a keen sharp musical note, easily read through much outside disturbance.

The revolving gap of Marconi, already referred to, also gave a fine musical note; but the ordinary fixed spark gap, working either from a coil or an alternator of commercial frequency, say 60 per second, was heard as a harsh note, which when faint by reason of distance was very easily swallowed up by extraneous disturbances.

Now, having shown them the bare bones of the receiving circuit, it was interesting to trace its refinement and development, which was curiously like the development of the sending circuit they had had in review.

The last diagram showed them the detector directly in the aerial circuit, and this was the first arrangement. He must pass by the fact that the earliest detectors were all specimens of the coherer, or imperfect contact, type. They were very troublesome in practice, and were now fortunately historic only in interest.

But it was found that whatever type of detector was used it was bad practice to put it directly in the air wire circuit, for the reason that by its high resistance it had a strong damping effect on the air wire, making it impossible to secure a sharply defined period of oscillation, which was necessary if it was to be responsive to given incoming signals.

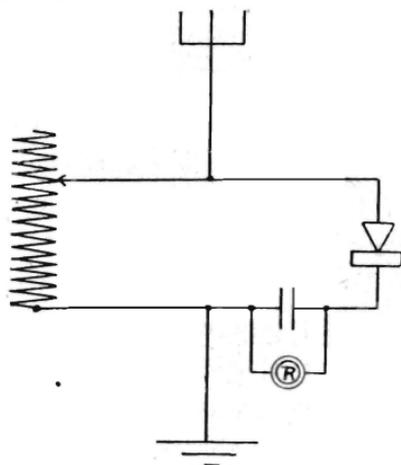


Fig. 11.

The next step, as shown in Fig. 11, was to put it in a derived circuit, shunting it round a variable tuning inductance which was used to bring the air wire to its proper period for reception.

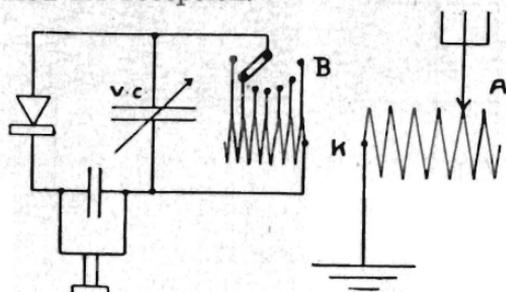


Fig. 12.

The next step, and they would recognise something familiar in Fig. 12, was to put the detector in a separate circuit altogether, leaving the air wire quite easily tuneable by means of a variable inductance, and with an uninterrupted circuit to earth. The inductance adjusting coil became a coupling coil or primary, with which was associated a secondary coil of, and circuit variable, both as to inductance and capacity, by means of switch contacts on to coils and a variable condenser, and therefore capable of being brought into exact resonance with the air wire circuit. The detector and phones were shunted round this secondary circuit in the usual way, and this arrangement constituted the receiving arrangements in a large number of Telefunken stations to-day. He should point out that the mutual relations of the primary and secondary coils are variable, one sliding within the other, the best signals being usually received when the coefficient of coupling in the receiving coils corresponded with that adopted in the transmitter primary and secondary. A further refinement of this circuit had been adopted by the Marconi Company in their tuner by introducing a third circuit, shown in the diagram, Fig. 13, as "D," which, being a closed circuit, could be calibrated and could therefore be used not only as a detector, but as a measurer of the arriving waves as well.

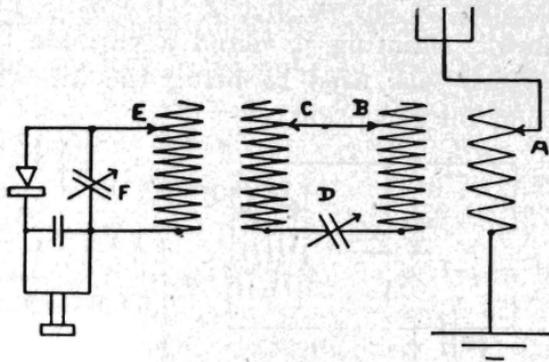
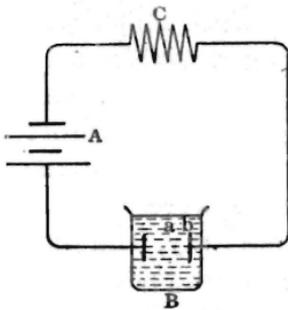
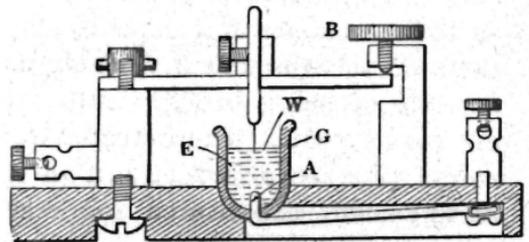


Fig. 13.

It was not possible within the limit of available time to deal exhaustively with the many types of detectors which had been contrived as part of a wireless equipment; but he proposed to refer briefly to examples of three well-marked types with which most of the world's wireless work was done to-day.



Professor Pupin's
electrolytic rectifier.

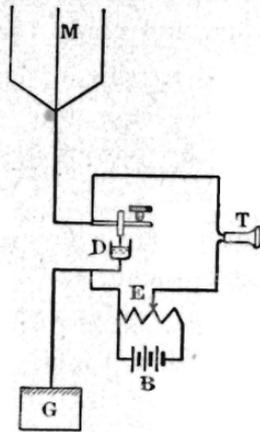


Electrolytic detector with adjustable contact.

Fig. 14.

First, the electrolytic detector. Here in Fig. 14 was a rough diagram of such a detector, which showed an extremely fine point of platinum dipping into a small vessel containing dilute nitric acid. The lever arrangement on which the fine platinum point was mounted was capable of fine adjustment by means of the milled screw, "B," and the point was arranged to just touch, and no more than touch, the surface of the liquid. The diameter

of the platinum wire was very small, between one one-thousandth and one two-thousandth part of an inch, a mere hair, and the cross section of this tiny anode was all that should be in contact with the acid when the detector was in adjustment. This contact was made part of a closed battery circuit with a pressure of about .1 of a volt, and the whole arrangement then became a small electrolytic cell.



Circuit with electrolytic detector.

Fig. 15.

The detector was introduced into the air wire circuit in the manner shown in Fig 15, which represented only the bare principles of the thing, and eliminated all timing coils, etc.

It would be seen that the air wire was shunted round the cell, and that a potentiometer arrangement was contrived to tap off the required voltage from the closed battery circuit, and pass it through the fine platinum of the electrolytic cell via the telephone.

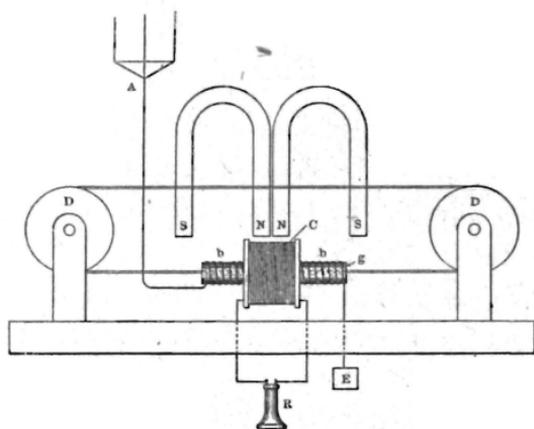
What happened was this: The air wire being at rest, slow electrolysis of the acid was going on. It was very slow, the current was weak, and the platinum point was

covered with minute bubbles of gas, which almost prevented the acid reaching it, and practically set up a very high resistance for the small battery current tapped through it. But let a wave strike the air wire and send a current surging up and down, and necessarily partly through the point, and the gas bubbles were instantly gone, a rush of current passed from the battery through the telephones, and a signal was heard. The moment the air wire was at rest the gas re-formed, and the detector was thus self-restoring, and ready for the next signal.

The great drawback to this otherwise very delicate form of detector was the ease with which the platinum point was burned out by powerful currents surging in the air wire.

He was experimenting one evening with an especially fine platinum wire at Mosman, and it was burned out by the "Drake" some twenty miles away at sea.

However, in spite of this trouble, much fine long distance work had been done with this detector in one or other of its forms.



Marconi magnetic detector.

Fig. 16.

Next for consideration was the Marconi magnetic detector, shown in Fig. 16, which was carried in every Mar-

coni equipment afloat, and which, while not highly sensitive, had the great qualities of extreme simplicity and great reliability.

A clockwork-driven endless band of fine iron wires passed through the coil "BB," which was directly in the air wire circuit, and through a strong magnetic field set up by the permanent magnets "N" and "S."

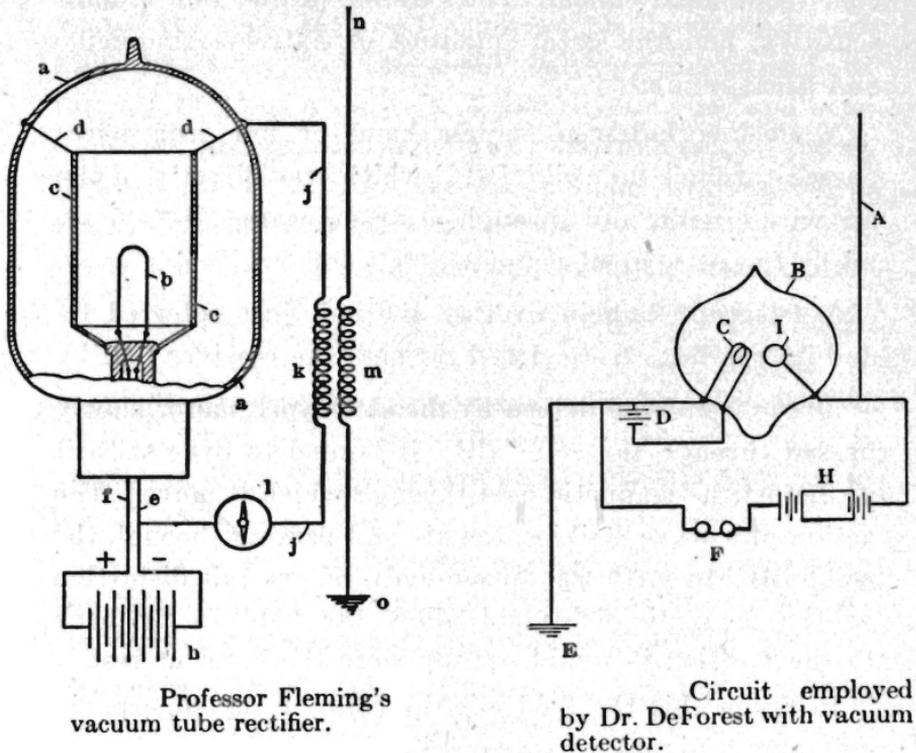
A telegraph bobbin overlay the coil just referred to, and its windings were closed through the receiver "R."

As the iron band driven by the clockwork motor slowly passed through the coil "BB" it tended to drag with it or distort the magnetic field through which it moved. The action of a wave striking the air and passing through the coil "BB" to earth was to suddenly relieve this distortion of the magnetic field and allow the field to fly back to the position it would occupy were the band at rest.

In doing this the field cut the coils of the superposed coil and a signal was heard in the telephone. It was rather interesting to note that this action was a sort of trigger action, the arrival of the wave merely releasing the distorted magnetic field which, by its own movement, gave the signal in the telephone.

The third and last type detector to which he should call their attention was a rectifying or valve detector, allowing current of only one sign to pass. This was illustrated in Fig. 17.

The carbon filament of an ordinary incandescent lamp was surrounded by a platinum cylinder or mantle within the exhausted bulb. The filament was made to glow by its own battery of cells, and the air wire was connected inductively with the platinum mantle and the filament, having in the connecting circuit the telephone receiver or measuring instrument "I."



Professor Fleming's
vacuum tube rectifier.

Circuit employed
by Dr. DeForest with vacuum
detector.

Fig. 17.

When the filament glowed negative electrons were sent off from it and filled the space between the filament and cylinder, rendering it conductive for a current, if the E.M.F. producing this current was directed from the cylinder to the filament. The space referred to was not absolutely impassable by a current tending to flow from filament to mantle, but so greatly so, compared with the ease of passage the other way, as to justify the term unilateral conductivity as applied to this region.

The action of one sign of the arriving wave was to reinforce the action of the battery E.M.F. in trying to cross from mantle to filament, and thus vary the flow of battery current through the detector "I," and give rise to an audible signal.